A MANUAL OF SURGICAL TREATMENT

A Manual of Surgical Treatment

By

W. WATSON CHEYNE

M.B., F.R.C.S., F.R.S.

Professor of Surgery in King's College, London; Surgeon to King's College Hospital, and The Children's Hospital, Paddington Green, etc.

and

F. F. BURGHARD

M.D. and M.S. (Lond.), F.R.C.S.

Teacher of Practical Surgery in King's College, London; Surgeon to King's College Hospital, and The Children's Hospital, Paddington Green, etc.

In Six Parts

PART I.

The Treatment of General Surgical Diseases, including inflammation, suppuration, ulceration, gangrene, wounds and their complications, infective diseases and tumours.
The administration of Anæsthetics, by Dr. Silk

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To

THE RIGHT HON.

LORD LISTER, LL.D., P.R.S.,

THE FOUNDER OF MODERN SURGERY,

WITHOUT WHOSE WORK MUCH OF

THIS BOOK COULD NOT HAVE

BEEN WRITTEN.

AUTHORS' PREFACE.

The subject of Surgery has now become so extensive that any work attempting to deal with it in an exhaustive manner must necessarily be so large and unwieldy as to be suitable only for purposes of reference, or for the use of those who devote themselves exclusively to its practice. In any text-book of convenient size the information given in certain branches of the subject must therefore be considerably condensed, and, as the first essential for the beginner is to have the fullest knowledge of the nature and characters of the diseases that he has to study, special stress is usually laid upon pathology, symptomatology, and diagnosis. For the practitioner, on the other hand, who is already acquainted with these points, the great essential is full and detailed information as to the best methods of treatment.

We have ourselves frequently experienced the want of detailed information, especially as regards the after-treatment of our cases, and have had to learn the best methods of procedure from experience. Nothing can of course replace experience, but it is often of the greatest advantage to have a detailed record of that of others upon which to base one's work. It is this want that the present work is intended to supply. We have tried to put ourselves in the place of those who have to treat a given case for the first time, and we have endeavoured to supply them with details as to treatment from the commencement to the termination of the illness. We have assumed that the reader is familiar with the nature and diagnosis of the disease, and we only refer to the pathology and symptoms in so far as it is necessary to render intelligible the principles on which the treatment is based, and the various stages of the disease to which each particular method is applicable.

We have purposely avoided attempting to give anything like a complete summary of the various methods of treatment that have from time to

time been proposed: to do so would merely confuse the reader. Only those plans are described which our experience has led us to believe are the best, but with regard to these we have endeavoured to state exactly and in detail what we ourselves should do under given circumstances. In some cases no doubt several methods of treatment are of equal value, and while we have only discussed at length that which we have ourselves been led to adopt, we have referred shortly to the others.

We have not mentioned all the exceptional conditions that may be met with, but we have endeavoured to include all the circumstances with which the surgeon is most commonly called upon to deal. The task has been one of some difficulty, the more so as we have had, to a certain extent, to break new ground. This must serve as our excuse for the many shortcomings in the work.

Our best thanks are due to Dr. Silk for much assistance in seeing this volume through the press, as well as for his contribution upon the administration of anæsthetics. We are also indebted to Messrs. Down Brothers for kindly placing at our disposal their very large collection of blocks illustrative of surgical instruments, to Messrs. H. K. Lewis for Fig. 63, to Messrs. Arnold for Fig. 64, to Messrs. Barth & Co. for Figs. 18 to 22, and to the *Medical News of New York* for Figs. 40 and 41.

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PART I.

CHAPTER I.

INFLAMMATION.

DEFINITION.—Inflammation may be defined as the first series of changes that occurs in a tissue as the result of an injury, provided always that this has not been of sufficient violence to at once destroy the vitality of the part. Whenever an injury is done to a part, whether it be of a chemical or a mechanical nature, a certain series of changes at once commences there, and this series of changes, so long as it is of an exudative or destructive character, we call inflammation. The amount of inflammatory change in the tissue will depend upon the length of time that the process goes on, and the severity and result of the inflammation will be in proportion to the length of time that the irritant exerts its influence, and the intensity with which it acts. Inflammation is divided into acute and chronic inflammation.

ACUTE INFLAMMATION.

PATHOLOGY.—It is only necessary here to enumerate the changes that take place in the tissues during inflammation. They consist in the first instance of dilatation of the blood-vessels, preceded in some cases by contraction. This dilatation affects more especially the small arteries and capillaries, but also to some extent the veins.

Results at early period.—In the early stages the circulation of the blood is quickened, but slowing of the blood-stream soon becomes evident, until, in severe cases, complete stasis or coagulation of the blood takes place within the vessels at the focus of the inflammation. During this period also, fluid collects in the surrounding tissues, which become much swollen. This fluid is probably in the main derived from the blood plasma, but in part it is lymph retained in the tissues; and not only does fluid accumulate outside the vessels and coagulate there, but the white corpuscles pass out in large numbers through the walls of the veins, and to some extent through those of the capillaries as well. In certain inflammations also, red blood-corpuscles may escape from the blood-vessels. At this stage, if the cause has ceased to act, the inflammatory process may come to a stop,

and the process known as resolution may set in. That is to say, the exuded material becomes broken up and removed by the lymphatic vessels, the migrated corpuscles either re-enter the blood-vessels or the lymphatics, or break down and are carried away in the form of débris. The dilated vessels also gradually regain their tone, and ultimately the part resumes its normal appearance and structure. On the other hand, in very severe inflammation, the stasis and exudation may be so great as to lead to gangrene of the part even at this early stage.

Results at later period.—In most cases inflammation that has gone on to this degree proceeds further, and the tissues gradually disappear as the result of the inflammatory process, the original tissue being replaced by what is known as granulation tissue. This is composed, in the first instance, of round cells and embryonic blood-vessels. The inflammation thus passes on to the stage of granulation, and when this stage is reached one of three things may happen. In the first place, the irritant may cease to act, in which case the process subsides and retrogressive changes take place. The cells which compose the granulation tissue then develop into fibrous tissue, and the blood-vessels diminish in number and become blocked by a process analogous to arteritis, but the ultimate result is the formation of scar tissue, and not restoration of the part to its normal condition, as is the case in resolution. More usually, however, where inflammation has gone on to the stage of granulation, we have to do with a more persistent cause of inflammation, and therefore suppuration results. Thirdly, where the inflammatory process affects the skin or mucous membrane, and is not very violent, the result known as ulceration follows.

SYMPTOMS.—We shall here deal with the early stages of inflammation, before suppuration or the other processes above enumerated have supervened. At this early stage the symptoms of inflammation are partly local and partly general. The **local changes** are diffuse redness of the part, most intense at the centre, and swelling, which sometimes reaches a marked degree, and varies in character at different parts, being hard and brawny towards the centre of the inflammatory area, and soft and œdematous towards its margins. There is also heat, and, lastly, severe pain, which is usually of a throbbing character, being worse where the inflammation affects dense tissues and when the part assumes the dependent position. The **general symptoms** of inflammation vary with its situation, extent, and nature, and present two great types. In the first type of inflammatory fever, which is termed the *sthenic* fever, there is headache and anorexia, the temperature is high, running up rapidly to 103° or 104°, the pulse becomes rapid, varying from 100 to 112, and is full, not easily compressible, and quite regular. The tongue is furred, white and moist, the skin is hot and dry, the bowels are constipated, and the urine is scanty and high-coloured. If delirium be present, as it very often is, it is of a noisy and violent character; in fact, the general type of this form of inflammatory fever is that of strong reaction, and the patient does not

present any marked features of depression. On the other hand, another type termed the *asthenic* inflammatory fever is met with in certain cases; of this the great characteristic is marked depression of the vital powers. The temperature, as in the other case, is high, but the pulse is quicker and may run up to 130, and is soft and thready and quite easily compressible. The tongue is dry and brown, delirium, if present, is of a low muttering character, and the patient is generally in a semi-conscious state.

TREATMENT.—The treatment of inflammation must be considered under the heads of local and general treatment. The great characteristic of the inflammatory changes is that they only continue as long as the cause which produces them continues to act. As soon as the cause ceases to act, the inflammatory changes very quickly come to a standstill, and then either resolution or retrogression takes place.

Removal of cause.—Hence, in the treatment of inflammation, the first great question is to ascertain whether or not it is possible to remove the cause. The causes of inflammation will be discussed more in detail under the heading of suppuration, but they may be divided, as regards treatment, into two classes, namely, those which are removable and those which are not readily got rid of. Removable causes are foreign bodies, chemical irritants, and the like. The irremovable causes are micro-organisms growing in the tissues, and they are, unfortunately, the more common. The action of these micro-organisms, however, is to a certain extent dependent upon, or influenced by, various circumstances which favour their growth. Therefore, if any foreign body or other removable cause is present, remove it, and if there is no cause that can be removed, try to put the tissues under the most favourable circumstances to resist the growth of the parasite, and, moreover, get rid of anything which is aiding its development.

Local Treatment.—The most obvious symptom in inflammation is the congestion of the part, and the first point in the local treatment of acute inflammatory trouble, in cases where the cause is irremovable, is to attempt to diminish this congestion as far as possible. If one succeeds in diminishing the congestion one will also lessen the pain and the exudation, and possibly also to some extent the constitutional disturbance.

Position.—The first way in which congestion of a part should be relieved is by attention to its proper position. When an inflamed part is allowed to hang down, the throbbing and the pain are very much increased, as the result of the dilatation of the blood-vessels. The first essential in the treatment of acute inflammation, therefore, is to raise the inflamed part so as to place it, if possible, on a higher level than the heart, and by this means to diminish the congestion, not only by the mechanical emptying of the veins, but also by the production of reflex contraction of the arteries.

Blood-letting.—A second method, by which the congestion of the part may be relieved and the local symptoms considerably subdued, is by blood letting, and this may be employed either in the form of general or local blood-letting.

(*a*) **General blood-letting**, or the removal of a considerable quantity of blood from the general circulation without any special reference to the seat of the inflammation, probably acts by lowering the action of the heart, producing faintness, and so diminishing the circulation in the affected part. It is also possible that the loss of a considerable quantity of blood may, to some extent, alter the constitution of the remaining blood serum, and render it more active as an anti-bacteric agent. General blood-letting, which was formerly much in vogue, is but seldom practised nowadays. It is best carried out by opening a vein, the one usually chosen being the median basilic vein, which is preferred to others on account of its constant large size and its ready accessibility. The patient should sit upright upon a couch, so that he can lie down immediately if he feels faint; the sitting position has the further advantage that the patient will become faint sooner than if he were lying down, and thus a certain safeguard is provided against the withdrawal of too much blood. Venesection should never be practised with the patient in the recumbent position. A bandage is tied in a bow round the upper arm, tight enough to cause engorgement of the veins, but not sufficiently tight to interfere with the arterial flow. The superficial veins are still further distended by making the patient grasp a stick, as by this means the blood is forced from the deep veins into the superficial ones. The surgeon stands in front of the patient, grasps the arm with his left hand, and steadies the median basilic vein by placing the left thumb upon it immediately below the intended seat of puncture, and then, with a sharp double-edged lancet, an oblique incision is made through the skin and the anterior wall of the vein, the posterior wall of which should not be divided. The incision should divide both the skin and the wall of the vein at one cut, and should be oblique to the long axis of the vein. The blood flows in a jet from the incision in the vein, and is received into a graduated porringer. It is generally the custom to slip the left thumb over the incision in the vein as soon as it is made, so as to prevent bleeding until the porringer is ready. The amount of blood usually withdrawn is from about eight to ten ounces; in former days the patient was bled until he felt faint or until he actually fainted. After a sufficient quantity of blood has been withdrawn, the bandage around the upper arm is removed, a small pad of cyanide gauze placed over the skin incision, and kept in position by a few turns of a figure-of-eight bandage. This suffices to arrest the bleeding, and in a few days the wound will be healed and the circulation re-established. The patient should be directed to keep his arm in a sling for four or five days. Although this is but a small operation, it is well to perform it with full antiseptic precautions, the patient's skin, the operator's hands and the lancet being thoroughly purified in the ordinary manner;[1] in former times patients occasionally lost their lives from septic thrombosis. The operation itself is perfectly easy, but care must be taken

[1] For the methods of disinfection of skin, instruments, etc., see Chap. VIII.

not to allow the knife to go too deeply, for it has occasionally happened that the brachial artery has been punctured by the lancet, with the result that aneurismal varix has subsequently formed. Another vein which used to be frequently opened is the external jugular vein as it crosses over the sterno-mastoid muscle, but the risk there is greater, because air may enter the vein and cause serious circulatory trouble. The operation in this situation possesses no countervailing advantages in the case of inflammation, and we shall not describe it.

(*b*) At the present day, however, we have to consider not so much general as **local blood-letting**, the former method being almost entirely restricted to such inflammatory conditions as those of the lungs, and sometimes of the brain, characterised by engorgement of the right side of the heart. The means employed for local blood-letting are threefold, namely, the application of leeches, the use of cupping, and incisions or scarifications. As to the manner in which local blood-letting acts, it is assumed that, by withdrawing a little blood from the skin in the neighbourhood of the inflammation, less blood is carried to the inflamed part, either because afferent vessels are cut, or, more probably, because reflex contraction of the other vessels takes place through the agency of the nervous system.

We shall first consider the application of **leeches**, with regard to which several points require to be mentioned. In the first place, the part to which the leeches are to be applied must be carefully cleansed, as otherwise they do not readily bite, and if there is any difficulty, the application of a little cream or milk to the skin will sometimes prove effectual in making them do so. When the leeches are put on the skin, it is very necessary to confine them until they have taken a good hold, because as a rule they do not bite directly they are applied. This is most conveniently done by inverting over them the bottom of a pill-box, from which the top has been removed. In a short time they will fix themselves, and the pill-box can then be taken away. Special leech-glasses are employed for this purpose, and they answer admirably; but in using them it is of course necessary to see that the leech is put tail first (the thick end of the leech) and not head first into the glass. This seems an unnecessary remark, but nevertheless the mistake is not uncommonly made by students. A narrow test tube answers the purpose of a leech-glass excellently. Several accidents have taken place where leeches have been left free, on account of their having wandered into mucous canals, such as the rectum or the vagina, and there caused considerable mischief. When a leech has been applied it is allowed to suck its fill, and the amount of blood which an individual leech will abstract is from a drachm to a drachm and a half. As a rule, when it has sucked as much blood as it will hold, it falls off, but should there be any delay in its detachment, it can be hastened by applying some salt and water to it. When a leech has been removed, and it is proposed to use it again, it should be placed for a short time in salt and water, and this has the effect of making it

vomit the blood which it has swallowed. The wound made by the leech is tri-radiate and does not extend deeply into the skin, and, were there no provision for preventing it, coagulation would occur, and very little blood be obtained from the wound after the leech has detached itself. In the throat of the leech, however, there is a gland secreting a substance which prevents the coagulation of the blood, and it is probable that the cases in which there is much trouble from bleeding after the application of leeches are explained by the fact that this secretion has been left in considerable quantity in the wound.

Bleeding from leech-bites.—As a rule, bleeding from a leech-bite stops very soon after the leech has been removed. In fact, in many cases warm fomentations have to be applied to the part if it is desired to promote additional bleeding. In some cases, however, the bleeding does not stop, and considerable trouble ensues from difficulty in arresting the oozing which goes on. Where it does not stop of itself, a pad and bandage properly applied will usually suffice, but, if not, the skin around the leech-bite should be pinched up, so as to stop the bleeding temporarily, and then the bite is carefully dried and flexile collodion painted over it and allowed to dry before the pressure is relaxed. If this fails, a hare-lip pin may be passed under the wound and a piece of silk firmly twisted over the projecting ends in a figure-of-eight. Should this be insufficient, it may be necessary to use some styptic, such as perchloride of iron, the small wound being pinched up to arrest the bleeding temporarily and the liquor ferri perchloridi applied to the cut surface. Even this may fail, and, if the bleeding still goes on, it is best to excise the leech-bite altogether, leaving a deeper wound which can be stitched together. The object of excising the leech-bite is to remove the tissue which is impregnated with the material from the leech's throat. In view of the possibility of the hæmorrhage proving troublesome, it is not advisable to apply leeches to a part which cannot be compressed against a bone. For instance, they should not be applied to the scrotum; if leeching is required in that situation the leech should be placed on one or other side of the perineum, where pressure can be applied against the pubic bone. Where it is required to apply leeches for affections of the eye, the best plan is to shave a little of the hair from the temple and apply the leech in that situation. Firm pressure can then very easily be applied, if necessary, and the hair when it grows again will cover the mark of the bite satisfactorily. Cases have occurred where, when leeches have been applied late in the evening, and the bleeding has not been noticed, the patient has lost a large quantity of blood by the morning. It is therefore well to apply them in the forenoon, so that bleeding may be readily observed.

The second method of blood-letting employed in inflammation is **Cupping.** For the purpose of actually removing blood, wet cupping is the plan used, but a good deal of benefit is in some cases derived from the employment of **Dry Cupping**, which consists in the application of the cups without any

previous scarification of the skin, and therefore without any loss of blood to the patient. Either the special cup which is sold for the purpose may be used, or a small tumbler, which answers equally well, and the edge of this should be oiled. A piece of blotting paper about two inches square is dipped in methylated spirit and placed in the bottom of the glass, and this is set on fire with a match. As soon as it has burned a few seconds the glass is inverted over the skin (which should previously have been sponged with warm water), and, as the heated air in the glass contracts on cooling, a partial vacuum is created, the skin and subcutaneous tissues being drawn up into the interior and forming a prominent mass full of blood. A number of cups may be applied in this way and left on for a considerable time. After a time, when the swelling of the skin has increased to such an extent as to replace the air lost by the heat, they become loose; but, should it be desired to remove the cups previously, this is quite easily done by insinuating the finger-nail beneath the rim of the cup, so as to allow of the entrance of a little air; the cup can then be readily lifted off.

Where **Wet Cupping** is employed, the skin is first scarified in a number of places, either by means of a special machine made for the purpose (see Fig. 1), or by means of an ordinary lancet. The incisions should not go deeply into the skin. It is sufficient to go deep enough to draw a little blood; if the skin be cut through, until the fat is exposed, small pellets of the latter will be drawn up and plug the orifices and stop the bleeding. The object is to open as large a number of capillaries as possible. When this is done, the cup is applied in the manner already described, directly over the scarified area. The result is that, as a consequence of the partial vacuum, blood is drawn out of the part until the place of the air is taken by the blood which issues from the skin; the cup then gets loose and can be removed. If further bleeding be required it can be promoted by the application of warm fomentations, or the scarified surface may be sponged free of clots and the cup again applied as before. Wet cupping is a most convenient method of withdrawing blood locally, but the quantity removed by each cup is comparatively small, being from one to three drachms. This method of treatment is especially useful in the lumbar region, for renal affections. There is no trouble in arresting the bleeding after wet cupping performed in the manner described.

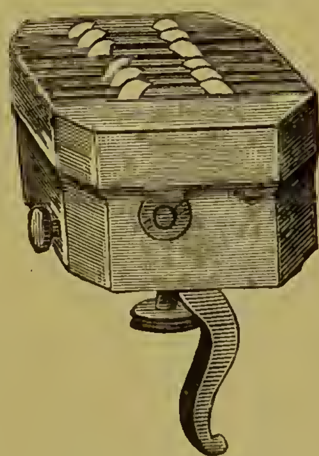

Fig. 1.—Scarificator for use in Wet Cupping. The instrument, with the blades concealed (which is done by pulling the large trigger handle), is pressed flat against the skin, and the blades are made to protrude by pressure on the button at the side of the figure. The depth to which the blades project is regulated by a screw seen at the bottom of the figure.

The last method of local blood-letting is that of scarifications and free incisions. The **Scarifications** are made by a lancet with the precautions

already referred to in describing cupping, and they are mostly used in cases of inflammation affecting mucous membranes. For example, in inflammation about the back of the throat, when there is œdema of the glottis, much good may result from early scarification of the part, which is carried out by means of a small curved lancet introduced through the mouth.

Free Incisions into an inflamed part will often prove of the very greatest value in acute inflammatory conditions, and they act not only by allowing the escape of blood from the engorged blood-vessels, but also by permitting the escape of the exudation, which might otherwise cause very much damage from pressure upon the blood-vessels. This is more especially the case in inflammations in dense tissues, such as the periosteum and bone, where the blood-vessels are confined within rigid canals, and where the pressure of the exudation in these canals may be so great as to obliterate the vessels, and so prevent the blood-supply reaching the bone. In commencing acute suppurative periostitis and osteomyelitis, it is imperative, if extensive necrosis is to be avoided, to make free incisions through the periosteum as soon as the case is diagnosed, and, in the case of osteomyelitis, to remove portions of bone so as to freely open the medullary cavity. If this be done with antiseptic precautions, a very considerable number of cases will be saved from the impending necrosis.

Cold.—Other methods of diminishing the local trouble in inflammation are the use of cold or heat. At first sight these methods may seem contradictory, but each has its use and neither can be altogether dispensed with. Cold is supposed to act by contracting the blood-vessels going to the part, and so diminishing the flow of blood through it. A certain amount of danger is associated with the use of cold, as the vitality of the tissues may be so depressed by it that, where the inflammation is severe, actual death of the tissue may follow its prolonged application, and this is a point which should be carefully borne in mind. Not only does the cold of itself depress the vitality of the part, but it slows the circulation so that the blood becomes venous, and thus in another way the nutrition of the part is interfered with. Hence the use of cold should be limited to the early stages of inflammation, for directly much exudation has taken place it is hardly likely that cold will arrest the further progress of the trouble, while the danger of weakening the tissue is especially great.

Cold may be applied in various ways. Probably the mildest form of using cold is by the application of one or other of the ordinary **Evaporating Lotions.** A good evaporating lotion consists of half an ounce of chloride of ammonium, one ounce of rectified spirit, and seven ounces of water. Another good formula is:

Ammonii chloridi, - - - - - - -	ʒss.
Aceti destillati, - - - - - - - -	ʒj.
Spiritus rectificati, - - - - - - - -	ʒj.
Aquam ad, - - - - - - - - -	℥j.

Misce. Ft. lotio.

A piece of thin muslin dipped in the lotion is placed over the skin and kept constantly moist, the part being left freely exposed to the air, so that evaporation may go on rapidly. The patient himself is generally able to look after this. Another lotion which is much used is lead lotion, or, where there is much pain, lead and opium lotion. The lead lotion is the liquor plumbi subacetatis dilutus of the Pharmacopœia, and in order to make the lead and opium lotion, 10 to 20 minims of laudanum is added to each ounce of the liquor plumbi. This is used in the same way as the above.

If greater lowering of temperature be required, dry cold should be used, because the wet form is more apt to lead to gangrene than the dry. Dry cold is best applied by means of an **Ice-Bag**, crushed ice being placed in an indiarubber bag, and the latter so suspended over the part that the weight of the ice does not cause pressure upon it. The ice, of course, will require renewal as it melts, and the condition of the ice-bag should be frequently inspected. A very convenient way is to tie the ice-bag to the

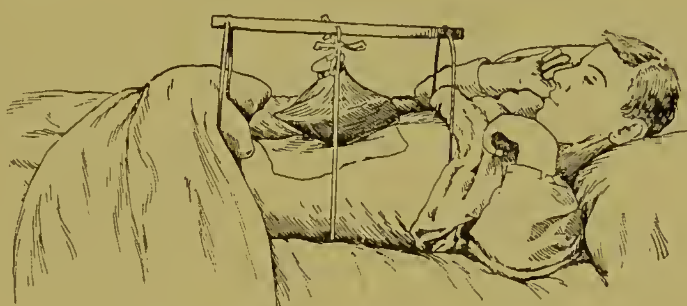

Fig. 2.—Method of applying an Ice-bag.

upper part of one of the cradles which are used for protecting limbs in the case of fracture, etc., and so arranging the height of the ice-bag that it just touches the part where cold is required. Between the ice-bag and the skin a piece of lint should be placed, in order to absorb the moisture which is apt to accumulate there (see Fig. 2). In employing cold in acute inflammation, the condition of the part should be carefully watched from time to time, and if the skin become dusky from excess of venous blood, or if the circulation in it be markedly slowed, as will be shown by pressing the part and watching the rapidity with which the vessels fill again, the use of cold should at once be abandoned and the part wrapped up in cotton wool.

A still more effectual way of employing cold is by means of the apparatus known as **Leiter's Tubes**. These consist of fine lead tubing which can be twisted into a flat spiral coil and then so moulded as to surround the part without causing any undue pressure. Through these tubes a constant stream of water is passed, and, according to the temperature of the water, any degree of cold can be obtained. Between the Leiter's tubes

and the skin a piece of lint should be placed, for the reason just mentioned with regard to the ice-bag (see Figs. 3 and 3A)

Fig. 3.—Leiter's Tubes. The illustration shows the method of using the tubes by coiling them in a spiral manner around the limb. They may be used in a similar manner in the case of the penis.

These tubes are particularly dangerous on account of the intense cold which may be produced by them, and it is seldom advisable to

Fig. 3A.—Leiter's Tubes. This form is the best for use upon most occasions. The tubes are coiled upon and fixed to a light flexible metal plate, and hence are not likely to become kinked or to leak. The metal plate is moulded to the surface and secured by tapes, a fold of lint being interposed between it and the skin.

leave them on an acutely inflamed part for longer than twenty-four hours at the outside. The condition of the circulation should be carefully

inspected every three or four hours. They are in reality of more use in bleeding or in great engorgement of the part than in inflammation. In using them for inflammation, it will be found that water at a temperature from 50° to 60° F. is usually quite sufficient.

Heat.—Where the acute inflammation has lasted for two or three days, cold will no longer be of benefit; on the contrary, it will be very apt to cause damage, and under these circumstances it is best to resort to the application of heat. The mode of action of heat is somewhat difficult to explain, but whatever be the explanation, it is certain that it is a very valuable agent in acute inflammation. Where the process actually affects the skin, heat is not so generally useful, on account of its tendency to increase the congestion of the part, and in these cases it should therefore be very sparingly used.

There are two methods by which heat is usually applied to the skin over an inflamed part, viz., by poultices or by hot fomentations. A **poultice** is usually made with linseed meal and water, the proportions being about four tablespoonfuls of linseed meal to half a pint of water. Care must be taken that the poultice is not too heavy, and as it very quickly loses its heat, special care should be taken to see that the bowl in which it is mixed, and the material on which it is spread, are well warmed previous to use. The poultice should be made and applied as hot as the patient can bear it, and as quickly as possible. In making it, the water employed must be boiling, and the linseed meal should be well stirred as it is added, to prevent the formation of lumps or hard masses. When mixed it is turned out upon a piece of linen of suitable size, previously warmed, and large enough to extend two inches all round beyond the poultice, and spread with a small spatula in an even layer about half an inch thick. The edges of the linen are then turned up around the margins and the poultice is ready for use. The whole operation should be carried on before a warm fire. In the case of superficial inflammation the poultice is applied next to the skin, but here it cannot be borne so hot as where the inflammation is more deeply seated. In the latter case it is usual to place a layer of muslin between the poultice and the skin, and in this way a greater heat can be tolerated. Having applied the poultice to the part, a layer of wool, heated before the fire, is placed outside, and the whole fixed on with a bandage or a suitable binder. A poultice of this kind will generally retain its heat for about two hours, and should then be changed. In changing it, a warm soft towel should be at hand, so that when the poultice is removed the skin can be dried and gently chafed with the towel, which is left in place, and the patient again covered with blankets till a fresh poultice is ready for application. If this be not done the part becomes very cold, and all the good of the poultice may be undone by the exposure. Other materials are used for poultices, such as bread or oatmeal, but if these materials are used a little butter or oil should be added, as otherwise the poultice is apt to become too hard.

There are various **advantages** and **disadvantages** in the use of poultices as compared with fomentations. The great advantage is that poultices retain the heat longer, and therefore it is not necessary to change them so frequently as fomentations, while, on the whole, they are considerably warmer. The chief objection arises in cases where a surgical operation will subsequently be necessary. The proper purification of the skin after a poultice has been used is a difficult matter, for the latter is a decomposing vegetable substance, which soaks into and penetrates the hair follicles, the hairs and the epidermis, and much scrubbing is required to disinfect the skin. Hence, where an abscess is likely to form, and when surgical measures may therefore be required, it is well to employ fomentations instead of poultices. With a view of obviating this septic difficulty, various antiseptics have been mixed with the poultice. Charcoal is sometimes employed, but this substance is simply a deoderant, and possesses no true antiseptic properties. Boracic, or carbolic acid are also sometimes mixed with the poultice. The best mixture probably is one of linseed meal and eucalyptus oil, but none of them are satisfactory from the antiseptic point of view, and hence, where an operation is likely to be required, fomentations should be substituted for poultices, at any rate for some days beforehand.

In the case of **fomentations,** the rules as regards the retention of the heat must be attended to even more carefully than in the case of poultices. A fomentation consists of a piece of flannel wrung out of boiling water, covered with a piece of mackintosh and a mass of wool; and the great point in the preparation of a fomentation is to apply it as hot as possible, and to prevent the loss of heat during its preparation. For this purpose it is well first of all to prepare a mass of wool considerably larger than the flannel and to place it in readiness before a warm fire. On the top of that place a piece of mackintosh with the mackintosh side outwards, sufficiently large to overlap the flannel in all directions. A well-warmed basin is then taken, a dry towel is unfolded and placed over it, and in the centre of this towel a piece of flannel of suitable size folded in two or four thicknesses is laid. Boiling water is then poured over the flannel, and, the ends of the towel being rapidly twisted up, the flannel is squeezed as dry as possible. No water must be left in the flannel lest the patient's skin be scalded. The folded flannel is then very quickly shaken out and placed on the top of the mackintosh, and then the whole mass—wool, mackintosh, and flannel—are lifted up and applied to the affected part as rapidly as possible. As soon as the patient can bear it, the mass is fixed on with a binder or bandage. The fomentation will usually require renewal in from half an hour to an hour, but it may be kept warm longer by placing an indiarubber hot-water bottle outside it, if the patient can bear the pressure. The precautions taken in renewing the fomentations are the same as those mentioned with regard to a poultice, that is to say, a warm towel must be at hand, with which the skin is at once dried and chafed

when the fomentation is taken away, and this is left *in situ* while the fresh fomentation is being prepared. In some cases, where there is much pain, a considerable amount of relief may be afforded by sprinkling on the surface of the fomentation, after it has been prepared, about half a drachm or more of laudanum, previously warmed by immersing the bottle in hot water. In other cases where the inflammation is deep seated, and a certain amount of irritation of the skin is desired, this may easily be obtained by sprinkling 10 to 20 drops of turpentine over the surface of the flannel, and thus making what is known as a *turpentine stupe.*

A special material, known by the name of **spongiopilin,** is sold in order to avoid the use of mackintosh in the application of the fomentation. It consists of thick felt covered on one side with an impermeable layer, and this is employed in the same way as the flannel in making the fomentation. As a rule, however, it is well to place mackintosh and wool outside the spongiopilin, as in an ordinary fomentation.

General Treatment.—The general treatment of the patient must be directed partly to the relief of symptoms such as pain, and partly to promoting the excretion of the poisonous materials absorbed from the inflamed area into the blood. The latter object is effected by attempting to dilute the poison in the blood by means of diluent drinks, and also by making efforts to assist the secretions from the skin, the bowels, and the kidneys.

The first point then, in the case of inflammatory fever, is to administer a **purgative**, and the best substance that one can use for that purpose is sulphate of magnesia or some other saline. The sulphate of magnesia is given in a dose of half an ounce or more, dissolved in as little water as the patient can comfortably swallow; the more concentrated it is the better is its effect. By its means at least one copious watery evacuation a day should be ensured. The purge acts partly by clearing out decomposing material from the intestine, and should be given even though the bowels have been previously acting quite regularly. It acts partly also by leading to transudation of a quantity of serum from the blood, and thus possibly removing a quantity of poisonous material. At the same time, the purgative probably acts also as a counter-irritant, and thus exerts a further beneficial effect. It will be evident, when we come to speak of chronic inflammation, that counter-irritation is a very potent agent in the treatment, and it is probable that poultices and fomentations act as counter-irritants.

Drinks.—The patient should be encouraged to drink a large amount of fluid, with the view of diluting the poison in the blood, and of leading to its rapid elimination by the kidneys. Milk should be given in large quantities—as much as from four to six pints a day if the patient can take it. The combination of milk with barley-water is good, as the latter tends to prevent to some extent the constipating effects of the milk. It also retards coagulation, and, if the patient is much troubled with the curdling of the milk in the stomach, lime-water may be added, or still better, one-

half to one drachm of the liquor calcis saccharatus to each tumblerful of milk. At the same time, the patient should be encouraged to take fluid drinks containing bicarbonate of potash or spirit of nitrous ether. A very good one is that used in most hospitals, and called "imperial drink"; it consists of one to one-and-a-half drachms of cream of tartar added to a pint of boiling water, and then allowed to cool, a little sugar being added to sweeten it. The cream of tartar may also be conveniently given in gruel, made by adding a tablespoonful of oatmeal and about a drachm of cream of tartar to half a pint of water, and boiling it, adding afterwards a tablespoonful of brandy and a little sugar. By these methods the kidneys are made to act without any undue irritation. Above all things, one must avoid the more irritating diuretics, on account of the tendency that there is in many of these acute inflammatory affections to albuminuria and nephritis.

Drugs.—The congestion may also be diminished by slowing the action of the heart, and this can, to a certain extent, be brought about by various drugs, notably by aconite. This drug should only be given in quite the early stage of the inflammation, and then it often gives marked relief. The dose should be one minim of the tincture every half hour for three doses, and then every hour for three or four more. This has the effect of slowing the pulse, reducing the temperature, and producing diaphoresis. The pulse must be carefully watched whilst the drug is being administered. If it becomes unduly slow, and especially if it shows signs of becoming weak or irregular, the aconite should be stopped at once, and if the weakness and irregularity are very marked, a hundredth of a grain of digitaline should be injected subcutaneously, and repeated in an hour or two if necessary. In the case, for example, of an initial pulse rate of 110, a reduction to a rate of 80 is as much as is desirable.

At night time, a Dover's powder may be given, partly with a view of obtaining sleep and freedom from pain, but mainly to promote the action of the skin. The latter object may also be furthered by giving liquor ammoniæ acetatis in two to four drachm doses every three or four hours.

The **food** should consist entirely of fluid, essentially of milk, with occasionally a certain amount of beef-tea; and, as the patient is apt to neglect to take a proper amount of nourishment, it is well to arrange for the administration of food about every two hours—a tumblerful of milk alternating with a cup of beef-tea or some Valentine's meat extract. During the period of recovery from the inflammatory condition, nourishing diet, with stimulants and tonics, more especially iron, should of course be given.

PROGNOSIS.—The prognosis of acute inflammation depends on its nature and seat. Should an acute inflammation, of the degree of which we have been speaking, last for more than three or four days, suppuration will almost certainly take place. If, on the other hand, the inflammation is subsiding, wrinkling of the skin is noticed, and a favourable prognosis as

regards the question of suppuration may in most cases be given, although sometimes, where an abscess has formed, wrinkling of the skin in its vicinity may be present, owing to the subsidence of the œdema.

CHRONIC INFLAMMATION.

NATURE.—Chronic inflammation may either begin as an acute process, in which the symptoms do not entirely disappear but gradually become much less acute and pass slowly into the chronic form, or, as perhaps more often happens, it is not preceded by the acuter form, but is chronic from the first. The process of chronic inflammation is somewhat difficult to understand and explain, because it generally forms part of some other morbid process, and it is not easy to separate one from the other.

CAUSES.—Like acute inflammation, the chronic form depends upon the continued action of some exciting cause, but the causes which produce chronic inflammation are not of the same violent nature as those which set up the acute inflammation with which we have already dealt. Among the causes of chronic inflammation may be mentioned the presence of a foreign body. For example, a bullet embedded in the tissues, provided that it has not carried in with it any pyogenic material, will set up chronic inflammation in the part, which may last for a considerable time after the lodgment of the foreign body. Any obstruction to the free exit of secretion from a gland, as for instance a stricture or a calculus in its duct, brings about retention of the secretion behind the obstruction, and this leads to a condition of chronic inflammation in the gland, which will continue until the obstruction is relieved, or until the gland undergoes atrophy. Chronic inflammation not infrequently results also from pressure, and ends in the formation of a quantity of new tissue, as is seen for example in callosities, which, forming in a part, subject it to much pressure. Then, again, various deposits from the blood are responsible for exciting a state of chronic inflammation; for example, in gout the deposition of urates in the tissues keeps up a condition of chronic inflammation in the neighbourhood of the deposit. In some cases, chronic inflammation seems to be dependent on certain states of the blood, the precise nature of which we do not exactly understand; as, for example, in rheumatism, where chronic inflammation of fibrous tissues very often occurs, and may continue for a long time. Perhaps the most common cause of chronic inflammation is the presence in the tissues of some morbid material, more especially the specific virus of one of the chronic infective diseases, notably tubercle and syphilis, and it is well to bear in mind that in these cases, especially in tubercle, the main part of the swelling in the area affected is due, not to the mass of tuberculous tissue, but to the chronic inflammation which its presence has set up.

CHANGES IN THE TISSUES.—The result of chronic inflammation is that a large amount of new connective tissue is formed. The part becomes

full of cells, many of which are undergoing transition into fibrous tissue, and with the cells there are, at the more recent points, young blood vessels in large numbers. A chronically inflamed tissue, of itself, never undergoes suppuration. If so-called suppuration occur in a part which is the seat of chronic inflammation, it is due either to acute septic infection, or to the breaking down of the morbid material which is causing the inflammation; this is especially the case in tubercle. A typical chronic abscess, which has not been acute at the commencement, is practically always tuberculous.

SYMPTOMS.—Of the symptoms of chronic inflammation, the most characteristic is the presence of swelling, which is due to the formation of a large amount of new connective tissue. For example, a bone which is the seat of chronic inflammation may become enormously thickened. In certain organs where there is much soft tissue, as in the liver, the final result of a chronic inflammation may be actual diminution in the size of the part, the large amount of new connective tissue formed in it undergoing contraction, and leading to atrophy of the normal cells. In most cases, however, swelling is a prominent feature. Of the other symptoms, the pain varies with the situation and is often but slight, although in bone it is a very marked feature, owing to the compression of the nerves by the exudation in the unyielding tissues. A certain amount of tenderness and heat are almost always present. The increased vascularity of the tissue is often evidenced by the enlargement of the veins on the surface, large dilated vessels running over the swollen part. Constitutional symptoms are not present as a rule. If they are, it is either because some vital organ is affected, or else they are due to the disease which is setting up the inflammation.

TREATMENT.—In considering the treatment of chronic inflammation, the first point is to ascertain whether or not we can **remove the cause**, for if this be effectually done, the inflammation will at once subside. Thus, in cases where a foreign body, such as a bullet, is embedded in the tissues, the indication is to cut down on and remove it. Similarly, where the chronic inflammation is caused by obstruction of a duct, this must be remedied; where it is due to a deposit from the blood, as in gout, or to some state of the blood, as in rheumatism, appropriate medicinal treatment must be adopted for the elimination of the noxious material from the circulation. Most commonly, however, as has already been said, the cause of the inflammation is the presence of some chronic infective disease, and it is not always easy to get rid of this completely, more especially where it is of a tuberculous nature. Where it is not possible or advisable to remove the cause, the treatment consists in taking various measures which are calculated to diminish the inflammation, and these measures are essentially local.

Local Treatment.—**Rest.**—The first essential point in the local treatment, after the question of removal of the primary cause, is to secure complete physiological rest of the part, and this is absolutely necessary

for the subsidence of the inflammation. If the seat of the inflammation be a joint, it should be fixed; if it be any part affected by muscular movements, rest must also be obtained, and always, if possible, in bed or in an elevated position. It has already been pointed out, with regard to acute inflammation, that the **position** of the part affects the congestion, and in chronic inflammation also, the relief of the congestion by the adoption of the elevated position is a very essential element in the treatment. Even although it may be impossible to remove the exciting cause (*e.g.* tubercle), much good may be done by taking steps to diminish the inflammation itself, because inflamed tissues are more easily invaded by the morbid process than healthy ones, and if this condition of chronic inflammation be diminished, the extension of the primary disease may thereby be checked.

In addition to rest, there are various other measures which are employed, of which perhaps the most important is **counter-irritation.** By counter-irritation is meant the application of an irritant to some superficial part of the body, usually to the skin, either over the seat of the inflammation or at a little distance from it, more especially to a part which is in intimate nervous connection with the inflamed area. Exactly how benefit results from the use of irritation of the skin is not at all evident; we can only suppose that the irritant acts in some way through the nervous system. As has already been mentioned in speaking of acute inflammation, the poultices and fomentations which are of such value there probably owe their virtue partly to the principle of counter-irritation, and they may be classed as the mildest counter-irritants with which we are acquainted. In cases of chronic inflammation, however, some more active agent is usually necessary.

Of the counter-irritants most commonly employed, we shall refer to mustard, iodine, blisters, and the actual cautery. Of these, *mustard* is the mildest, and is employed either in the form of mustard leaves or as a plaster. The mustard leaves, which only require damping before being applied, are very handy and cleanly, and are generally used when the effect of counter-irritation alone is required. As a substitute for them, the ordinary mustard plaster, made by mixing mustard with tepid water into a thick paste and spreading the mass thus obtained on a piece of linen or brown paper, may be employed. In using either of these preparations, the guide to the length of time that they should be left on is the patient's sensations. Generally they will require removal in from ten to twenty minutes; if left on longer than that they are apt to blister, and special care should be taken not to leave them on too long in the case of young children, in whom they may produce actual sloughing. If, in addition to the counter-irritation, the warm poultice action be also required, a mustard and linseed poultice may be employed. The simplest plan is to make the poultice with boiling water in the ordinary way (see p. 11), using one part of mustard to four parts of linseed meal. If a still more

energetic action be required, an ordinary linseed poultice is made, and over the surface of it mustard is thickly dusted, and the poultice then put on.

The most popular method of counter-irritation is the use of *tincture of iodine* or of *linimentum iodi*, the part being painted with the iodine every day until the skin becomes so sore that the patient cannot go on with it. As a rule, however, the effects of iodine are not satisfactory, and in many cases of tuberculous glands, in which it is so commonly used, it is positively harmful, as it tends to bring about suppuration. The two most potent methods for producing smart counter-irritation are blisters and the actual cautery.

Blisters may be produced either by the use of the ordinary emplastrum lyttæ of the Pharmacopœia, or by means of the liquor epispasticus. Before applying them the part should be thoroughly cleaned, and if there are hairs they should be shaved off. In the case of adults the plaster should be left on for about ten hours. The length of time which it will require to produce its effect varies, however, with the thickness of the skin. In parts where the skin is thin, or in the case of children, a considerably shorter time—about five or six hours—will generally be sufficient; on the other hand, where the skin is thick, as on the palm of the hand or the sole of the foot, the blister may even require twenty-four hours in order to rise. After the plaster is removed, the part is generally the seat of a good-sized blister. Sometimes, however, the skin is merely reddened, or at most one or two small vesicles only are present; the subsequent application of a fomentation or a poultice will ensure the proper rising of the blister. If, however, it does not rise properly in the course of a few hours, painting the skin with the liquor epispasticus and allowing it to dry will usually produce a satisfactory result. Some prefer the liquor epispasticus alone, painting it over the part and allowing it to dry two or three times in succession. It must be freshly prepared, as otherwise it is very uncertain in its action. The effect of the fluid may often be increased by rubbing a drop or two of croton oil over the surface before application.

Precautions.—Besides taking care not to leave the plaster on too long for fear of causing sloughing of the skin, we must bear in mind the danger that the patient runs of absorbing the drug, in which case there is considerable risk of nephritis. Blisters should not, therefore, be applied over large areas where the skin is delicate, and should not be used at all where there is any renal disease. As to the best position for applying the blister, it is well, where the inflammation is still active and is affecting the skin or the subcutaneous tissues, not to apply it immediately over the seat of disease, as otherwise it would probably increase the congestion of the part, and thus augment the inflammation. It is better in these cases to apply it at a little distance away. Where the inflammation is subsiding, however, there is not the same objection to applying it directly over the affected area; on the contrary, the increased flow of blood and lymph which is

thus set up may, so to speak, wash out the part and aid the absorption. Where the inflammation is more deeply seated, the best effect is usually produced by applying the blister directly over the spot.

The *actual cautery* is one of the most potent means of producing counter-irritation, and it is used either to form one large sore or a number of small ones. The formation of a large sore is probably the more effectual method. In cases of spinal disease, for example, the production of a superficial sore on each side of the spine, two or three inches in length and a couple of inches in breadth, will often do a great deal of good. Similarly, in hip-joint disease, two sores, one in front and one behind the joint, will often relieve the acute starting pains from which the patient suffers. Only the superficial part of the skin should be acted on, as it is important that the whole thickness should not be destroyed. In order to

FIG. 4.—FLAT CAUTERY. The flat surface is generally used, but the edge can be employed if it be desired to score lines upon the skin.

produce these large sores effectually, and without too much destruction of tissue, it is best to use a flat, iron cautery—such as that depicted above (see Fig. 4)—heated to a white heat, and for this an anæsthetic is generally necessary. If not at a white heat, it is difficult to gauge the amount of destruction of the skin produced; one may easily do either too much or too little. As a matter of experience we know that, where a cautery is used white hot, it suffices to rub it quickly two or three times over the part in order to produce the desired amount of burning. All that is wanted is to destroy the epidermis and portions of the rete mucosum, and thus lay bare the terminations of a large number of nerves. After the cautery has been applied, poultices or hot fomentations should be used until the slough separates, which will occur in four or five days. If now the wound were left to itself, or merely dressed with some simple ointment, it would heal with great rapidity, because the skin, not being deeply destroyed, there are numerous points from which epithelium would quickly spread over the part. As a matter of fact, however, it is necessary, in order to get the best effect from the use of the actual cautery, to keep the sore open from four to six weeks. This can only be done by the application of some irritant ointment to the sore after the slough has separated. The ointment usually employed for this purpose is savin ointment, but many patients are unable to bear, for any length of time, the pain caused by the pure savin ointment, and hence in most cases it is necessary to dilute it with an equal part of simple ointment, or to add about 10 per cent. of cocaine. Even where savin ointment is used healing

often occurs too rapidly, and if this be the case it may be necessary to destroy the young epithelium on the surface of the sore from time to time with nitrate of silver, or, if that does not suffice, to apply potassa fusa. If this latter application is required, a stick of potassa fusa is held in a pair of forceps and quickly rubbed over the part, which is then covered with lint steeped in vinegar. In many cases where much pain is present it is remarkable how quickly it disappears after the application of the cautery, and how, if the wound be allowed to heal too rapidly, the pain will at once recur.

Another form of cautery is that known as *Corrigan's cautery*, or the button cautery (see Fig. 5). This is a small, round, metal button fixed

FIG. 5.—CORRIGAN'S CAUTERY AND PORTABLE SPIRIT LAMP FOR HEATING.

in a handle, and is also heated to a white heat and pressed for a moment on the part which is to be burned, and by its means a number of little sores are produced. Where the proper cautery is not at hand, the same effect can be produced by the broad blade of a Paquelin's cautery. An anæsthetic is not, as a rule, necessary in this case. The effect is not so good, at any rate in extensive inflammation of bone, as where the larger cautery is employed.

In former times a variety of *other methods* were used for the production of counter-irritation; for instance, croton oil was rubbed over the part, either alone or in the form of a liniment consisting of one part to eight of oil. This was used chiefly in chest cases, and the result of such an application is the production of a pustular eruption. Tartar emetic ointment, in a strength of one to five of simple ointment, acts in a similar manner and causes a pustular eruption. Setons were also formerly much used, that is to say, a piece of silk or worsted threaded upon a suitable needle was passed through the skin and left there after the needle had been cut off, the result being that a suppurating sinus formed, which could be kept open for any length of time. The objection to the use of the seton is that a septic wound is produced which may seriously injure the patient, and may be the starting point of one of the acute septic diseases.

There still remain two other methods of great value in the treatment of chronic inflammation which require mention. The first of these is **free incision** into the part, and this in many cases is of the utmost value For example, in chronic inflammation of the periosteum there is nothing

that relieves the pain and improves the condition so much as a free incision, which should of course be made aseptically. The effect of this is much increased if a portion of the thickened periosteum is also taken away. Similarly, in chronic osteitis the best method of treatment is to gouge away a large portion of the inflamed bone, even although the whole of the area affected be not removed. The rest very soon improves, and the patient is much relieved, and often cured. From the point of view of diagnosis, also, it is of much importance to bear in mind the great value of free incisions as a curative agent in cases of chronic inflammation, because in many cases it is difficult to be certain whether one has to deal with a chronic inflammation or a tumour. Knowing, however, that free incision into a chronically inflamed part is one of the best means of treating the inflammation, one need not hesitate to ascertain at once the state of matters by making a free incision into the part. If it turns out that we have a tumour to deal with, the diagnosis is made, and the surgeon can then proceed to treat the case as is required. If, on the other hand, the case proves to be one of chronic inflammation, the very best thing has been done to cure the patient.

Pressure is also a good deal employed in cases of chronic inflammation, but it is mainly of value when the process is subsiding. If much pressure be applied to a part in which active inflammation is going on, it is very apt to increase the latter instead of diminishing it. But where the inflammation is subsiding, pressure is one of the very best means to employ. For example, in cases of thickening of the epididymis after acute epididymitis, strapping the testicle is the favourite and best method of treatment. Pressure is also a good deal used in cases of chronic inflammation of joints, whether dependent on tuberculosis or not, and it may be carried out in various ways, the essential point being that the pressure should be equable and not too great. Perhaps the best way to obtain firm, equable pressure is to surround the part with a large mass of cotton wool or silk waste in even sheets or layers, without any lumps or irregularities, and then to apply a bandage over it as tightly as possible. To prevent the bandage becoming loose afterwards, some starch or silicate of soda solution should be rubbed into it. This method will be referred to more particularly when we come to speak of joint diseases. In some cases an elastic bandage is applied outside the wool, but if this be done it must not be put on too tightly, for the elasticity multiplies the force considerably. Another way in which pressure is applied, especially in joint diseases, is by means of *Scott's dressing*, in which we have a combination of pressure and counter-irritation. Scott's dressing consists of the compound mercury ointment (*unguentum hydrargyri co*) spread upon chamois leather. The chamois leather is cut into strips and applied, like other forms of strapping, in imbricated layers around the diseased part, the application being made quite firmly. Outside this a layer of cotton wool and a firm bandage are applied, and the limb placed on a splint. Another method

of applying Scott's dressing is to spread the ointment upon a sufficiently large piece of lint, cut this into strips, and apply them to the limb in the usual imbricated layers. Outside these, ordinary strapping is applied in a similar manner. A splint is not always necessary. The part should be shaved before the strapping is applied, and the dressing should be renewed every four or five days, both because the skin is apt to become raw, and also because the strapping slips and the dressing becomes loose.

Lastly, we have to consider **massage** in relation to chronic inflammation. Massage is chiefly of value where the inflammation has come more or less to a standstill, and where it is a question of causing absorption of the inflammatory products. If employed during the active stage it is apt to make matters worse. The essential principles of massage are, in the first place, to break up the products of the chronic inflammation, and, in the second place, to promote the absorption of the broken up materials by the lymphatic vessels. Various actions are employed with the view of breaking up the new material. The mildest form is what is termed "friction massage," that is to say, with two or three fingers of one hand the part is rubbed in a circular manner for some time, in order to break up the exudation, and then the material is forced into the lymphatic vessels by an upward and more uniform pressure, which is called "effleurage." In effleurage, the part which has been subjected to the friction is grasped with the whole hand, more especially between the thenar and hypothenar eminences, and is firmly and gently squeezed in an upward direction. This is repeated a good many times, and then again the friction is resumed, and again the effleurage follows. Where the material is more difficult to break up, another action, called "petrissage" or firm kneading of the part, is resorted to. The part is grasped between the fingers and the thumb, and is firmly kneaded, and then, following the kneading, the broken up products are forced into the lymphatics by the action of effleurage. Lastly, where the material is still more dense, and more especially where it is limited to a small area, the action of "tapotement" is employed, that is to say, the part is firmly tapped, either with the fingers or a special instrument, and, after repeated and violent tappings as hard as the patient can bear, effleurage is again carried out. At first, massage should be very gentle, but, as the patient becomes accustomed to it, the more forcible measures may be adopted. As a rule, a sitting of twenty minutes once a day is sufficient, but after three or four days, if distinct benefit results, there may be two sittings daily, morning and evening, and as time goes on the length of the sittings may be increased to three-quarters of an hour or an hour at a time. The length of time required for a cure, of course, entirely depends on the nature of the case and the progress made: except in extensive and obstinate cases, three weeks generally suffice. Massage is especially useful after inflammation which causes adhesion either between muscles, or between tendons and their sheaths, or in joints or wherever much thickening is left after inflammation or injury.

General Treatment.—The constitutional treatment in chronic inflammation will depend rather on the disease which is at the bottom of the process than on the process itself. It is of course very essential that the patient should be put under the best possible hygienic conditions, and that he should have plenty of fresh air. Food of the most nourishing character should be ordered, and, in cases where the patient is weakly, stimulants should be administered. As regards medicines, the usual remedies for gout, rheumatism, syphilis, etc., may be employed as required. Even in some cases not due to syphilis, iodide of potassium and mercury are administered in small doses, but as a rule these do not then produce any marked effect.

To sum up, therefore, we have the following means at our disposal in the treatment of chronic inflammation, viz. : the removal, or at least the appropriate treatment, of the cause; then rest, position, counter-irritation, free incisions, pressure, massage, and general treatment. Of these latter, rest, position, and good hygiene and nourishing food are essential in all cases. Of the various other methods free incisions, made aseptically, are the most certain and speedy, but in many cases they may not be necessary or advisable. Under such circumstances, resort may be had to counter-irritation, or, if the inflammation is not very active, to the use of pressure. In very inactive cases, or during subsidence of the trouble, pressure and massage are of great value.

CHAPTER II.

ACUTE SUPPURATION.

DEFINITION.—By acute suppuration is meant a process where the inflammation, after reaching the stage of granulation, goes on to liquefaction of the tissues and the formation of pus. Pus is a fluid containing in suspension cells resembling leucocytes, and it may either form in the substance of the tissues where the inflammation is deep-seated, or be given off from a free surface. We shall only consider here the question of suppuration as it occurs in the substance of the tissues. Suppuration from a free surface will be discussed later, in connection with the treatment of wounds and ulcers.

SUPPURATION IN THE TISSUES.—Suppuration in the tissues occurs under two forms. In the first, the pus is contained in a well-defined cavity with a distinct wall formed of granulation tissue; in the second, it infiltrates the cellular tissue and there is no proper limiting membrane, the tissues being, so to speak, soaked with the purulent material. The former is the ordinary circumscribed acute abscess, the latter is a much more dangerous form of suppuration, and is known as diffuse cellulitis.

Causes.—Acute suppuration is always due to the pyogenic organisms, the circumscribed abscess being more especially caused by the staphylococcus pyogenes aureus or albus (and in some rare instances by other less virulent forms), diffuse cellulitis by the streptococcus pyogenes. Although these organisms are the essential cause of acute suppuration, it must be borne in mind that they will not necessarily of themselves cause suppuration unless present in large numbers or in a state of extreme virulence. In most cases other accessory factors which favour the growth of the organisms are present, as, for example, conditions which enable the organisms to rest in the part, or which produce a weak spot in which the tissues are less resistent than elsewhere. Thus, it is not uncommon to find acute abscesses forming in parts which have been injured, or have previously been the seat of inflammation, the tissues there being in a weak state and less able to resist the attack of the parasite. The organisms reach the part either directly through a wound, or indirectly through the lymphatic vessels or the blood stream. Usually, in the case of an acute abscess the entrance is more or less direct. The organisms may gain entrance to the blood either

through wounds, or they may pass through an unbroken surface which is no longer quite healthy. This is more especially the case with the intestinal mucous membrane, and it is not uncommon, in cases of acute suppurative periostitis or osteomyelitis, to obtain a history of diarrhœa or some other intestinal derangement immediately preceding the onset of the trouble.

Circumscribed Acute Abscess—Symptoms.—When an acute inflammation which has gone on to granulation has lasted for four or five days, it is almost certain that suppuration will occur. When this takes place, the centre of the brawny swelling softens, and fluctuation can very soon be detected. Where the abscess is subcutaneous, the skin ultimately gives way over the soft spot, and pus escapes. Where the abscess is deep-seated, the presence of pus may not be easily recognized at an early period, but when the acute symptoms have lasted for several days and there is œdema of the skin over the part, this is generally sufficient indication of the presence of pus.

Mode of Extension.—When an acute abscess has formed, it spreads along the tissues which possess the greatest vitality, the extension not being a mechanical process due to the pressure of the pus, but an active and vital one. This is what is known as the "burrowing" of the abscess. Where an abscess forms beneath the skin, it spreads to this structure, as the skin is the tissue in which the vital processes are most active, and it ultimately bursts through it in preference to burrowing along the subcutaneous cellular tissue, which is less vascular and not so quickly converted into granulation tissue. Where an abscess forms beneath a dense fascia the conditions are different. The fascia is not so quickly converted into granulation tissue as is the areolar tissue beneath, and, consequently, an abscess so confined, if left unopened, will extend for long distances and in various directions beneath the fascia. Ultimately, however, the fascia undergoes granulation, or sloughs from interference with its blood supply by the pressure of the pus, and the latter escapes into the subcutaneous tissue. As soon as this takes place the abscess behaves like a subcutaneous one and bursts through the skin. The mode in which the abscess burrows is of great importance from the point of view of treatment. If an acute abscess be left unopened until a late period it will be found to be no longer a single round cavity, but one containing numerous diverticula corresponding to the directions in which the inflammation has extended in the deeper tissues. Unless these diverticula are thoroughly opened up, the mere evacuation of the superficial portion of the abscess will often fail to arrest the progress of the suppuration. Perhaps the best example of this is in the breast, where the abscess is rarely found to consist of a single cavity, but usually possesses many diverticula, corresponding more or less to the ducts and lobules of the breast. If an abscess of this kind be not opened in the manner to be presently described, the pus in these diverticula will be retained, and may lead to fresh openings, the ultimate result being that the whole of the breast becomes riddled with sinuses.

Treatment—**Local.**—When pus has formed it should be evacuated as soon as possible. If allowed to remain unopened the abscess will go on spreading, and thus cause a great deal of unnecessary destruction of tissue, besides in some cases imperilling the patient's life. Hence, when symptoms of acute inflammation have lasted for several days, and more especially if there be œdema of the skin over the part, and still more if rigors have occurred, no time should be lost in making an incision to find the pus.

In opening an acute abscess all the usual antiseptic precautions should be taken, the hair being shaved, the skin purified, and so forth, in the manner described for the treatment of wounds (see Chap. VIII.). At first sight this may seem an unnecessary precaution, because these abscesses, being due to pyogenic cocci, already contain the causes of suppuration. Practically, however, it is found that it is of the greatest importance to treat the abscess strictly antiseptically from the first. As a matter of fact, when an abscess is opened antiseptically it is comparatively easy to keep it aseptic, and no further suppuration occurs. On removing the first dressings there will no doubt be a small quantity of pus, but this is only the residual pus which was present in the abscess at the time of the opening, and if the cavity be squeezed, all that is expelled is a small quantity of clear serum; this rapidly diminishes, and in a few days the abscess cavity closes. On the other hand, where the abscess is not treated antiseptically from the first, suppuration goes on. If, for example, a poultice be applied, it will be found that, whenever the poultice is removed, pus can be squeezed out, or will even flow out spontaneously; this is evidently due to fresh infection of the cavity, for, when asepsis is maintained, the organisms which originally caused the abscess, for reasons into which we need not enter here, die out.

Opening an Abscess.—The incision into an acute abscess should always, if possible, be made at the most dependent spot. Unless the abscess is situated in parts such as the face or the neck, where the size of the scar may be a matter of importance, the incision through the skin should be sufficiently free to allow the surgeon to introduce his finger, with the view of exploring all the recesses of the abscess cavity and breaking down all the septa to which reference has just been made: without the aid of touch this cannot, as a rule, be satisfactorily done. In some cases where the abscess is superficial, and the size of the scar a matter of great importance, it is allowable to make a small incision just large enough to admit a pair of dressing forceps and subsequently to put in a small drainage tube. Before doing this, the forceps introduced into the interior of the abscess cavity should be pushed in all directions and the blades frequently expanded, so that any septa present may be broken down and the cavity thoroughly opened. In certain situations, as, for instance, in the anterior triangle of the neck, where the use of the knife in the deeper tissues would endanger important structures, some surgeons prefer to use the plan known

as *Hilton's method.* In this the skin only is incised, the knife is then laid aside, and, with a pair of dressing forceps, or Lister's sinus forceps, which are similar to dressing forceps but with much finer blades, the deeper tissues are carefully bored through until the pus is reached. When the forceps have entered the cavity, the blades are expanded until a sufficient opening has been torn in the tissues to enable a drainage tube to be introduced. As before, the forceps should be pushed into the cavity in all directions and the blades frequently expanded so as to break down septa. When an abscess has been opened in this way, a probe should be passed along the side of the forceps before their withdrawal, so as to act as a guide for the subsequent introduction of the drainage tube. If this be not done, the opening in the fascia through which the forceps entered may be missed, for it is not always in a direct line with the opening in the skin. The simplest way of introducing the drainage tube is to thread it over this probe; the lower end of the tube is grasped with the sinus forceps and gradually pushed into the abscess cavity, and then, whilst the forceps hold the tube in position, the probe is withdrawn.

Drainage.—Having opened the cavity of the abscess freely, and having made sure that no diverticula remain, the pus should be gently squeezed out, violence being avoided lest the granulation tissue should be injured. An india-rubber drainage tube, which should always be as large as can be conveniently introduced—the larger the better in the first instance—should then be inserted so that the end of the tube projects freely into the cavity; and this end should be perforated with a number of large openings through which the discharge can escape. Where the abscess cavity is very small, and does not extend to any depth, the use of a drainage tube may be dispensed with, and a narrow strip of gauze, dipped in a 1-2000 sublimate solution, laid between the lips of the incision throughout its entire length. This suffices to keep the wound open sufficiently for drainage, and may be discarded in a few days. Where the abscess is very large, and especially where the pus has burrowed to a considerable distance, it is often necessary to provide a second, or counter opening, to ensure efficient drainage for the pus; this is more especially necessary where the original opening has not been made at the most dependent point of the abscess cavity. To make a counter opening, a pair of sufficiently long dressing forceps are inserted into the cavity with the blades closed, passed down to the most dependent point, and then thrust forcibly outwards so that they project beneath the skin. An incision is then made through the skin over them, the points exposed, the blades separated and made to grasp a drainage tube, which can thus be pulled through the aperture. The outer part of the drainage tube should be cut off flush with the skin, and stitched to it if the patient is under an anæsthetic. This is the simplest plan for securing a drainage tube, and the most certain to keep it in its place. If the patient has not had an anæsthetic, it suffices to pass a loop of thread

through the outer edge of the tube, so as to have a means of pulling out the end of the tube should it slip too far in; this also helps to prevent the tube from slipping in because of the friction of the thread upon the dressing. It may be rendered still more secure by passing some strands of dressing through the loop. Another simple plan is to transfix the end of the drainage tube by means of a sterilized safety pin. It is well not to push the tube quite down to the bottom of the cavity, more especially if stitched to the opening, because it will be found that the swelling very rapidly goes down, and in the course of twenty-four hours a tube which hardly reached the bottom of the cavity will be pushed up, sometimes for a considerable distance, pulling the skin with it. So long as the tube enters the abscess cavity, or any recess which may require drainage, it is sufficient.

The plan of washing out acute abscesses after they have been opened is not one to be recommended. It can do no good whatever in the way of disinfecting the abscess, whilst it is very apt to injure the granulation wall, and thus produce a weak spot in which the organisms, which would otherwise die out, can spread. Similarly, any curetting of the cavity is to be strongly deprecated. This, of course, only applies to cases of acute abscess, and more especially to those where efficient drainage has been provided. In some cases where the anatomical conditions of the part do not allow of openings being made at the lowest point of the abscess cavity, as, for example, in certain abdominal abscesses, it is necessary to syringe out the cavity frequently, with the object of removing discharges which otherwise would collect and decompose at the lower parts of the wound. This may be done with warm 1-2000 sublimate solution, or, if the discharge be very foul, with sanitas or Condy's fluid. It will be seen when we come to speak of the treatment of chronic abscess that curetting, which is inadmissible in cases of acute abscess, is a valuable method of treatment there.

Dressings.—After the drainage tube has been inserted, the cyanide dressings recommended for wounds (see Chap. VIII.) should be used.

After-Treatment.—In the after-treatment of an acute abscess, the dressings should, as a rule, be changed on the following day, when it will be found that the swelling has considerably diminished. The drainage tube should not be removed, for if this were done it might be difficult to get it back, but if it is being pushed forward the retaining stitches should be cut and the projecting portion removed. A fresh dressing is then applied, the orifice of the wound and the skin around being previously washed with a 1-2000 sublimate solution. The question as to when the dressing should again be changed will be determined by the amount of discharge. With a small abscess the second dressing can usually be left on for three or four days. Where, however, the abscess was large, and where there is a considerable amount of serous oozing, it is well to change the dressing on the following day. In most cases the drainage tube can be left out on the fourth or fifth day, but the point which determines this is the amount of serous discharge present. If small, there need be no hesitation in leaving

out the tube; but if the discharge is still considerable, or purulent, the drainage tube should be continued. At any rate, a tube long enough to extend from the orifice of the skin to the entrance of the abscess cavity should be retained, as otherwise the skin wound is very apt to close with great rapidity, and the fluid will then be retained in the interior, and lead to the reproduction of the abscess.

There are various points in regard to acute abscesses in various situations which will be referred to in their proper place, such as the line of incision to be made, and the various difficulties that may arise in opening them. Suffice it here to recall attention to the essential point in the opening of the abscess, namely, the thorough breaking down of all septa which may shut off diverticula which would not otherwise be properly evacuated.

General Treatment.—The general treatment of acute abscess is the same as that described under acute inflammation (see p. 13). As soon as convalescence begins, nourishing diet, fresh air, stimulants, etc., are necessary.

Diffuse Cellulitis.—The other form of acute suppuration in the cellular tissue to which we have already referred, is diffuse cellulitis, where the pus is not contained in a well-defined abscess cavity, but infiltrates the tissues. This condition is due to the presence of the streptococcus pyogenes.

Symptoms.—Not only is there infiltration of the tissues with pus, but death of some portions of them very often occurs, and these dead portions come away afterwards as sloughs. The **local** inflammatory condition spreads with great rapidity, the skin becomes red, brawny, and, as suppuration occurs, boggy, but it is very difficult to make out any distinct fluctuation, at any rate in the earlier stages. Later on, however, it is not uncommon to find that, in addition to the infiltration of the tissues with pus, there is somewhere or other a distinct fluctuating cavity. The infection tends to spread along the lymphatic vessels, so that from quite an early period red lines are seen extending up the arm, for these abscesses most commonly occur in the fore-arm and hand, in connection with scratches upon the hand or fingers. As the infective material spreads along the lymphatic vessels, it not infrequently bursts through their walls at various parts, leading to fresh patches of diffuse cellulitis, and thus to fresh areas of inflammation, and it is not uncommon for the condition to terminate in pyaemia.

The **general** symptoms accompanying this local condition are very grave, presenting the characters of asthenic inflammatory fever, already referred to (see p. 3).

Treatment—Local.—The local treatment must be prompt and radical, and should consist in giving free and early exit to the pus and sloughs. A small incision in this case would do no good whatever, because the pus is infiltrating the tissues, and could not escape through such an opening. It is absolutely essential that the **incision** should be free, and should extend

right through the whole of the inflamed area. If one incision does not suffice to lay the whole of it open, additional ones must be made till the entire area is incised; in any case it should expose the deep fascia of the part, and must go even deeper if necessary.

After the incisions have been made, the part should be gently squeezed, and any recesses from which pus wells out should be thoroughly opened. When the surgeon is satisfied that all the recesses have been opened, extremely satisfactory results are often obtained from sponging the surface of the wound with **undiluted carbolic acid**, with the view of destroying the micro-organisms if possible. When the wound has been thus treated, it should be stuffed with strips of cyanide gauze wrung out of a 1-2000 sublimate solution and sprinkled with iodoform, and then the ordinary antiseptic dressing applied outside (see Chap. VIII.).

After-treatment.—Where, in spite of this treatment, the process does not come to a standstill, resort should be had to constant irrigation or the employment of the water bath, fresh incisions being made from time to

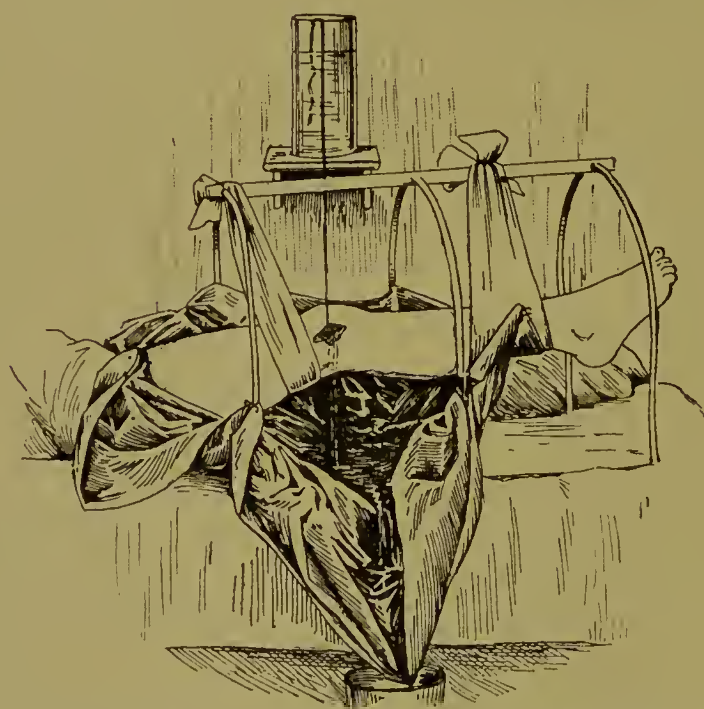

Fig. 6.—Constant Irrigation by means of a strand of worsted. The method of arranging the mackintosh so as to drain off the fluid is also shown.

time over any area showing signs of extension of the inflammation. To carry out *irrigation* the first point to remember is that whatever apparatus is used to convey the fluid, it must not allow the latter to drop on to the wound, as this would cause intolerable pain in a very short time. If a tube be employed, the end of it must lie upon the skin at the highest point of the wound. Perhaps the simplest and best plan is to convey the fluid to the wound by means of capillary action. A vessel containing the lotion is placed at a higher level than the part, and a strand of worsted,

one end of which hangs in the lotion, while the other lies on the upper part of the wound, is employed: the fluid runs along these threads very quickly, and the wound is thus constantly washed with it (see Fig. 6). The liquid used for irrigation should be at about the temperature of the body, and this can be arranged for by keeping a night-light under the vessel in which it is. It is well to add some antiseptic, but it is important to avoid those

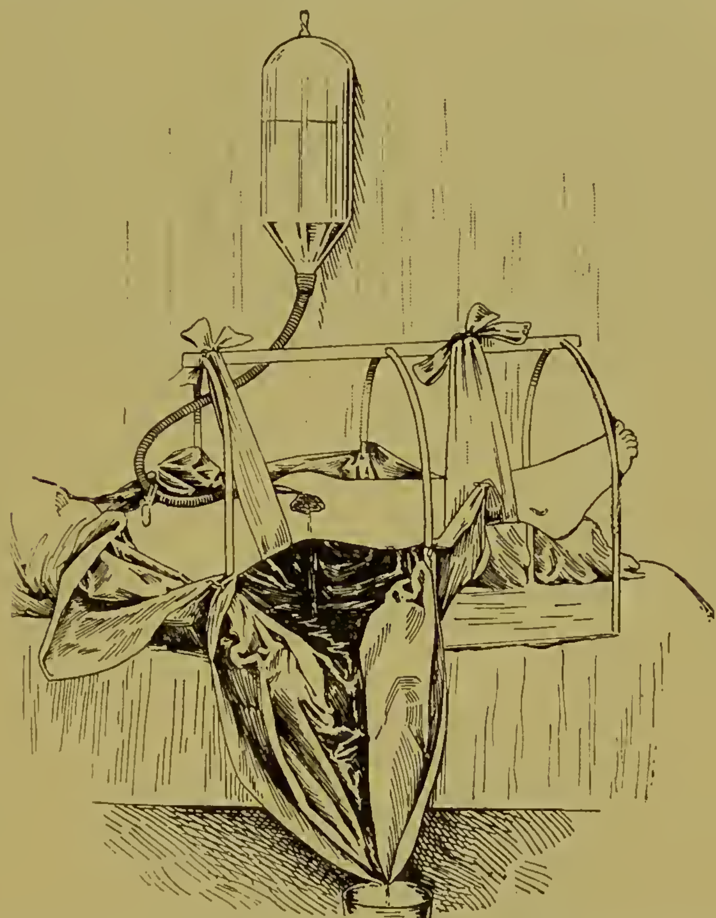

Fig. 7.—Constant Irrigation. The method of forming a drain for the surplus fluid by means of the mackintosh is also shown. The nozzle of the irrigator should always lie, as represented above, in direct contact with the edge of the sore.

which precipitate albumen; otherwise the surface of the sore will become coated with a layer of coagulated albumen, and the pus and organisms will accumulate beneath it instead of being washed away. Perhaps the best for the purpose are permanganate of potash or sanitas (a teaspoonful of sanitas to the tumbler of water, or two to four grains of permanganate of potash to the ounce). In irrigating, care must of course be taken not to wet the bed, and a mackintosh should be so arranged that the fluid is conducted into a basin at the bed-side (see Fig. 7). If possible, it is well to have the limb suspended over an empty vessel, but in any case a piece of mackintosh should be arranged beneath it. Of course, as in all other inflammations, the limb should be placed at a higher level than the rest

of the body. In the case of the arm, it may be made to rest upon a pillow, covered with mackintosh, the upper end of which is carefully tucked around the shoulders of the patient, and the sides so folded that a drain is formed which will prevent the bed from becoming soaked. In Fig. 8 is shown a simple method of extemporizing an irrigator where none of the ordinary forms are available. Another precaution which is necessary in employing irrigation, is to prevent the neighbourhood of the affected part becoming soddened with water, and for this purpose the skin all around may be smeared with grease or oil. Irrigation should be continued until the acuteness of the inflammation has passed off, and then it should be changed for some simple dressing; otherwise the granulations are likely to become œdematous, and a weak or œdematous ulcer is formed which will not heal properly. Perhaps the best dressing at this period is weak boracic ointment (about a quarter the strength of the pharmacopœial ointment) spread on butter cloth, with a layer of boracic lint applied outside, or else the protective and boracic lint dressing which will be described under the treatment of ulcers (see p. 47).

FIG. 8.—IRRIGATOR. To show how an irrigator can be improvised from a wine bottle: the bottom of the bottle should be cut off and the neck plugged with a cork which is traversed by a piece of glass tubing. (After *Thiersch.*)

Another very good method of treatment, although hardly so satisfactory as irrigation, is the *water bath.* In irrigation the main principle is that, the secretions being washed away as rapidly as they form, no nidus remains in which micro-organisms can grow. In the case of the water bath, the discharges are not washed away so rapidly as by irrigation, but they are so diluted that the organisms do not find satisfactory pabulum in them; at the same time the bath supplies warmth and moisture in a very efficient manner. In either case, if an antiseptic, such as sanitas, permanganate of potash, boracic acid, or weak iodine, be added to the fluid, there is also a certain amount of inhibition of the growth of the organisms.

In employing the water bath, the limb is suspended, by means of a large gauze or muslin sling, in a covered bath (see Fig. 9), filled with water at a temperature of about 100° F. and containing one of the above antiseptics in solution. The bath should be furnished with a tap at the lower part, and a gentle stream of warm water (at 110° F.) should flow through it by means of a syphon apparatus, from a reservoir above the level of the limb; every ten or twelve hours the bath should be emptied and flushed out, as otherwise the fluid is very apt to decompose. The skin around the wound should be carefully oiled. The water bath should only be used during the day, and during the night boracic lint, wetted with boracic lotion and covered with mackintosh, should be applied in the same way as a water dressing. The bath requires constant attention in order to

keep the water warm, to prevent it from overflowing, and to empty it from time to time, etc., and, therefore, the patient would be disturbed and unable to get proper sleep if the bath were employed during the night. Further, the limb must, in any case, be removed from the bath at the end of ten

Fig. 9.—Water Bath for Leg. The sloping floor of the batb is meant for the leg to rest upon: it is better, however, to have holes bored through the sides of the bath near the top, to which can be fastened slings of muslin in which the limb rests. The bath, when in use, is covered over with a thick blanket to maintain its temperature.

or twelve hours, so as to have the latter thoroughly scrubbed out; moreover, prolonged soaking in warm water does not improve the resisting power of the tissues. Where the feet or the forearm are affected, a water bath works very well, but, in the latter case, the patient must be propped up more or less in a sitting posture.

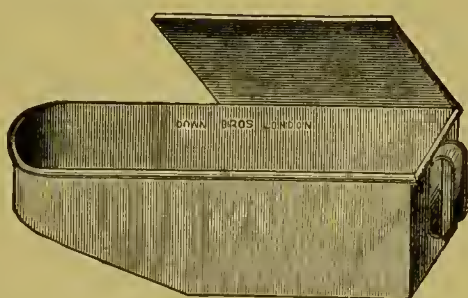

Fig. 10.—Water Bath for Hand and Forearm. The apparatus works more satisfactorily if it be furnished witb a tap, as in Fig. 9.

Where the upper part of the limbs or the trunk are affected, the patient must lie in an ordinary bath arranged for the purpose. In this case, if the trunk be not entirely submerged, care must be taken, by means of a blanket fastened round the neck and covering in the bath, to prevent any risk of the patient taking cold.

Failing the use of irrigation or the warm bath, the next best treatment is by *moist dressings*, consisting of boracic lint wrung out of warm boracic lotion, or weak sublimate solution, and applied over the whole surface of the wound, and then covered with a piece of mackintosh larger than the lint, and extending beyond it in all directions. This requires to be changed

frequently, as often as three or four times a day, and the wound and the skin around should be washed with a 1-2000 perchloride solution when the dressing is changed. When the acuteness of the symptoms has passed off, dry dressings, that is to say, boracic lint applied wet and allowed to dry, or else weak boracic ointment, are the best treatment. When healing has commenced the ointment is undoubtedly better, because the dry boracic lint is very apt to stick to the sore and, when the dressing is changed, to tear off the newly-formed epidermis. Where ointments are used they must be spread on thin muslin and changed once or twice a day.

Certain other points must be attended to in the local treatment of diffuse cellulitis. It is of primary importance that the part should be placed absolutely at *rest*, if necessary on a splint, and the *position* of the limb should be so arranged that, should stiffness take place, as it is very apt to do, the limb will be in the position most convenient for the patient. For example, in the case of the hand the fingers should not be stretched out, because if they become stiff in that position they are useless; they should be about half-bent over a pad, and the thumb especially should be kept apart from the fingers, and allowed to drop. If the thumb be kept at the same level as the fingers, and stiffness result, the power of opposition is more or less lost; whereas, if it be allowed to drop below the level of the fingers, then, even with comparatively limited movement, fairly small objects can be picked up between the fingers and thumb. To lay the whole hand flat on a splint, with the thumb at the side of the fingers, is a mistake so commonly made that too much attention cannot be called to it. The elbow or the foot should be put up at a right angle, the knee very slightly flexed, etc.

Passive Motion.—When the acuteness of the inflammation has passed off, steps must be taken to prevent any subsequent stiffness of the part, for in diffuse cellulitis, spreading as it does in the planes of the cellular tissue, and accompanied, as it very often is, by sloughing, the parts are very apt to become adherent to one another. Thus, in the forearm, what with the inflammation causing adhesion of the muscles to one another, and what with gangrene of portions of the muscle or even of the tendons, the hand is likely to be permanently useless. Hence, directly acute symptoms have passed off, the splint must be given up, and, to a certain extent, rapidity of healing must be sacrificed to the attempt to promote movement. The patient should be encouraged to move the fingers, the wrist, and the elbow joint, two or three times daily, and in addition to this, passive movement of these parts ought also to be carried out at least once or twice a day.

Massage.—As soon as possible after the wound has healed, massage and passive and active movements should be steadily persevered in, with the view of getting rid of the effused material, and of freeing the adhesions between the muscles. This massage is carried out on the principles already alluded to (see p. 22), and it should be accompanied by passive motion,

with the view of breaking down adhesions in the joints and between tendons. In bad cases, this passive movement may be undertaken two or three times a week under an anæsthetic, but care must be taken not to do too much at a time, as otherwise fresh effusion is caused, and the object of the procedure is defeated.

General Treatment.—The general treatment of diffuse cellulitis must be very carefully attended to. As has already been said, it is a very grave disease, and the patient is very apt to pass into the typhoid state, hence free stimulation is above all things necessary, and perhaps the best stimulant to employ is brandy. Where the patient, however, is very much exhausted, champagne will, at any rate temporarily, have a better effect. If brandy be given, at least six ounces should be administered in the twenty-four hours, and in some cases where the pulse is very weak, a considerably larger amount may be necessary. Strychnine injected hypodermically is also of great value. Every attempt should be made to promote the patient's nourishment, and this must be carried out on the lines already laid down for the treatment of acute inflammation (see p. 13).

Diffuse cellulitis in certain situations, *e.g.* scalp, neck, etc., will be treated of in their appropriate places. The essential facts to remember with regard to diffuse cellulitis in general are the rapidity of the disease, the necessity for very early surgical intervention, and the desirability of extremely thorough measures. As a matter of fact, one is much more likely to do too little than too much in the way of free incisions into the part.

CHAPTER III.

ULCERATION.

DEFINITION.—An ulcer has been roughly defined as any breach of the skin or mucous membrane which does not tend to heal. This definition includes, however, not merely ulcers proper, the result of inflammatory processes, but also ulcerating tumours, with which we shall not deal in the present chapter. True ulceration is an inflammatory process, and a more accurate definition is, that an ulcer is a progressive loss of substance in skin or mucous membrane which has previously been the seat of inflammatory changes that have gone on to granulation. This continued loss of substance is not due to death of visible portions of tissue (in which case there would be gangrene), but to degeneration of cells, or death of microscopic portions of the tissue—what is known as molecular death.

CLASSIFICATION.—There are two great classes of ulcers proper, namely, (1) those which are not due to any specific virus, but are caused by various local troubles, such as imperfections in the blood supply or innervation of the part. This class may be spoken of as the chronic non-infective ulcer. (2) Those in which a specific virus is at the root of the ulcerative process; this includes a large group of ulcers, by far the greater number being the result of syphilitic or tubercular disease. These are the chronic infective ulcers. In these latter there is, preceding the ulcerative process, a formation of new tissue which has a special tendency to undergo degeneration; for example, syphilitic nodules undergo gummatous degeneration, and tubercles undergo caseation, the result of these degenerative changes being ulceration. These chronic infective ulcers will be discussed more in detail in speaking of syphilis, tubercle, etc.; here we shall only deal with the chronic non-infective ulcers which result directly from inflammation.

CAUSES.—Before proceeding to discuss the treatment of ulcers, it is necessary to consider the causes which lead to the ulcerative process, and the various types of ulcers they produce. The causes of ulceration are mainly local, and among the chief is anything which tends to produce *defective circulation* of blood in the part. For example, if an inflamed limb hangs down, the return of the venous blood is impeded; consequently less arterial blood flows to the part, and its nutrition is therefore

interfered with: this is the explanation of the fact, that the great majority of ulcers affect the lower extremities. A granulating wound on the leg is very apt to become the subject of an ulcerative process if the patient continue to walk on the leg, or to stand about much, or even to hang it down. Perhaps one of the most frequent causes of ulceration is the presence of varicose veins, more especially where the veins affected are the small branches in the skin. Under these circumstances, there is a very marked obstacle to the venous return; consequently there is great stagnation of blood and the nutrition of the part is impaired. Again, apart from any venous obstruction, ulceration may also result from imperfect blood supply, as is seen in the cases where there is atheroma of the arteries, and if, to the presence of this disease, the dependent position be superadded, the ulcerative process may go on rapidly. This imperfect blood supply may also be brought about by the pressure of the inflammatory exudation in the tissues around the ulcer interfering mechanically with the circulation of blood in the part. This is more especially the case where the sore is situated over loose connective tissue, the meshes of which become distended with lymph and which is, moreover, sparsely supplied with blood-vessels.

In addition to these causes depending upon defective circulation of blood, ulceration is greatly favoured by *a feeble condition of the tissues* such as occurs in old age. A wound on the leg in a young subject, even although he has varicose veins and still continues to walk about, is not nearly so likely to lead to an ulcer as is a similar injury in an old person; this is, to a great extent, due to the greater vitality and recuperative power of the tissues in the young. At the same time, in old persons there is generally a diminution in the arterial supply, and thus there is a combination of at least two of the causes of ulceration. A similar result is brought about by anything which temporarily enfeebles the vitality of the part, such as severe and long-continued exposure to cold. This, short of producing gangrene, may lead to rapid ulceration.

Another local cause which leads to ulceration is *movement*. Where a sore is situated over a muscle, or over a fascia which is in frequent movement, more especially if adherent to either, ulceration is more likely to occur than in one situated elsewhere.

Another very frequent cause of ulceration is *difficulty in the contraction of the sore*. When a wound heals by granulation, an important element of the healing process consists in the diminution in the size of the sore, from the contraction of the newly formed fibrous tissue; when this contraction cannot occur, a time will come, especially if the sore be large, when healing will cease and ulceration will take place. The constant unsuccessful efforts of the new fibrous tissue to contract, seem to irritate the part and arrest the healing. This inability to contract may result from the great size of the sore, or from its adhesion to tissues, such as a bone or a dense fascia, which do not permit of contraction, or from induration of the margin of

the sore, as in a callous ulcer. Not only does the difficulty in contraction lead *per se* to ulceration, but the new tissue, in contracting, compresses the blood-vessels going to the part, and so interferes with the proper blood supply.

Again, *irritation* of a sore may lead to ulceration instead of healing, either mechanically, as by pressure, by friction of the dressings, etc., or chemically, as by irritation due either to the lotion used in the treatment, (for example, carbolic acid), or to decomposing secretions. Where the discharge from a sore decomposes, irritating materials are formed which may lead to extensive ulceration, especially if they do not readily escape. This is most often the case where the discharge dries up and forms crusts: under these crusts this decomposing, irritating secretion accumulates, and ulceration instead of healing occurs. Hence it is of great importance in treating an ulcer, or a septic granulating wound, not to permit the formation of crusts or scabs.

Ulceration may also be set up by accidental *contamination* of the wound. A wound which is healing will begin to ulcerate if virulent pyogenic organisms attack it; they lead to the formation of an inflammatory ulcer. Among other specific infections of sores may be mentioned diphtheria and phagedena, the latter of which will be dealt with more fully in connection with gangrene.

Ulcers also occur in parts where the *nervous supply is imperfect*; for example, after paralysis or neuritis. To some extent this may be due to the fact that the patient's cutaneous sensibility is diminished, and thus he tolerates greater and more continued pressure on one particular spot than the tissue can bear: the loss of the regulating trophic influence of the nervous system is also, without doubt, of great importance.

Lastly, ulcers may occur in connection with certain *constitutional conditions*, such as diabetes, scurvy, etc. Diabetes leads to ulceration, partly from the diminished blood supply due to the endarteritis which so often accompanies it, and partly from the increased susceptibility of the tissues to septic infection. Scurvy leads to extravasation of blood into the tissues, interfering with their vitality, and often ending in sloughing of the skin.

Summary of causes. In regard to treatment, the various causes which lead to ulceration may be most conveniently divided into six great groups. (1) The nature of the tissue. Where the tissue is loose and not very vascular, its vitality is not great, and the blood supply is more readily interfered with by the exudation. (2) Anomalies in the circulation, either local or general; such as local anæmia or venous hyperæmia, venous obstruction and pressure of exudation upon the vessels, etc. Under this heading may also be included ulcers in old people, where the tissues are less vascular and the vessels diseased. (3) Local disturbances of innervation, due to various diseases of the central or peripheral nervous system. (4) Local irritation, long continued or frequently repeated, mechanical or

chemical. The chemical causes are decomposing secretions or improperly selected lotions. (5) Local conditions, such as the seat of the sore, its size, its form, its relation to surrounding parts; the tension of the neighbouring skin; fixation of the sore to the parts beneath, to the fascia or bone; marked difference of level between the margins of the sore and its surface, etc. (6) Local disturbances, such as acute inflammation, phagedenic infection, etc., or general conditions, such as diabetes, scurvy, or other similar affections.

VARIETIES.—Various forms of ulcers are described, of which the following may shortly be mentioned: (1) **Simple Ulcer.**—This may be described as a granulating wound which is not healing. These sores are kept from healing by various local causes such as pressure or friction from the dressings, muscular movements, scratching, interference with the vascular supply, chemical agencies and so forth. In the early stage, the simple ulcer forms flat sores covered with granulations of a yellow or brownish-red colour, on a level with the surrounding skin or only slightly depressed beneath it. The margins are sharply cut, the surrounding parts are slightly œdematous. These ulcers extend fairly rapidly where no proper care is taken. In certain cases, these and other ulcers may become the seat of acute inflammation, and then we have the second form, namely, the inflamed ulcer.

(2) **Inflamed Ulcer.**—This is an ulcer which has become the seat of acute inflammation, as the result of some mechanical or chemical irritation, of bad methods of treatment, or, most usually, of septic infection. In these cases the surface of the ulcer becomes intensely red and angry-looking, it bleeds readily, secretes a large quantity of pus, extends with great rapidity and is not infrequently covered with small shreds of actually gangrenous tissue; the skin around is bright red and œdematous, the borders are irregular and eaten away, and it is not uncommon for fresh ulcers to develop rapidly around the margin of the original sore. These fresh ulcers are at first separated from one another, and from the original sore, by bridges of skin, which are sometimes quite narrow, intensely inflamed, swollen, and very apt to slough.

(3) **Irritable Ulcer.**—This form of ulcer is sometimes met with in neurotic women as a small sore with a somewhat elevated surface, and intensely tender to the slightest touch. It commonly occurs about the external malleolus, and is usually associated with menstrual disorders.

(4) **Weak Ulcer.**—A simple ulcer is very apt to become a weak one as the result of defective blood supply, either from too small a quantity of blood reaching the part, or from deficient quality of the blood, as for example where ulcerations occur during the progress of some constitutional disease. There are various kinds of weak ulcers, depending upon the cause producing them. In one form, the granulations become smooth and somewhat yellowish, the secretions thin, small in amount and very apt to form a scab, and the edges pale and flat. In a second form, the granulations

become œdematous, and this usually happens in connection with some general cause of œdema, or some local interference with the circulation, more especially the venous return. In a third form, the granulations show excessive growth; this generally occurs when the ulceration is due, either to the inability of the sore to contract, or to irritation from the materials used for dressing. In such cases the granulations become prominent, vascular, soft, and bleed readily, and the condition is one popularly spoken of as "proud flesh."

(5) **Diphtheritic or Phagedenic Ulcer.**—Any ulcer may be attacked by some specific virus, such as the diphtheritic, or with that which produces phagedena. In the latter case its surface becomes covered with a greyish, pulpy material, which rapidly infiltrates the surrounding skin and cellular tissue, extends both superficially and deeply, leads to extensive and very rapid destruction, constitutional infection, and not uncommonly ends in the death of the patient.

(6) **Varicose Ulcer.**—This is a type of ulcer which originates in connection with varicose veins, more especially where the smaller veins of the skin are affected. This condition of varicosity of the smaller veins leads to imperfect nutrition of the skin, and either to the occurrence of a local dermatitis ("varicose eczema") or to a periphlebitis and the formation of a small abscess around the vein: the abscess bursts, and gives rise to an ulcer. In the eczematous variety, the patient usually scratches the irritable part and produces a wound, which becomes inflamed and rapidly develops into an ulcer. However produced, these varicose ulcers are usually, at first, small and superficial, with œdema around, and with soft, prominent, and somewhat œdematous granulations. If the patient continues to walk about, the condition gradually passes into that of

(7) **Callous Ulcer.**—As a result of the continued interference with the venous return, local œdema takes place; there is exudation of coagulable lymph in the interstices of the cellular tissue, and cells accumulate there, the result being that the arterioles are much pressed upon, and the nutrition of the sore interfered with. The exuded material coagulates, and to a considerable extent becomes organized, and hence the skin and subcutaneous tissues around the ulcer become very much thickened, so that the surface of the ulcer comes to lie at a considerably lower level than its edge; this is not really due to extension of the ulcer in depth, but rather to the elevation of the surrounding part owing to the great thickening. Thus, the characteristics of a callous ulcer are—a sore at a deeper level than the surrounding skin, a hard indurated condition of its base and of the surrounding part, and a surface of a pale yellow colour, devoid of granulation, and secreting a small quantity of thin fluid.

(8) **Hæmorrhagic Ulcer.**—This is a form of ulcer which occurs more especially in patients suffering from scurvy; the surface of the sore is red, swollen, and bleeds readily, and the blood sometimes coagulates on the surface, forming a firm clot which was formerly spoken of as "bullock's liver."

(9) **Pressure Ulcer.**—This form of ulcer occurs in the sole of the foot, and is the result of long-continued but not necessarily severe pressure. In the first place, the pressure leads to thickening of the epidermis and the formation of a callosity, and underneath this callosity inflammation and suppuration occur. When the thickened epidermis is removed, a deep sore with great hypertrophy of the skin around the edge is exposed.

(10) **The Paralytic Ulcer** is one that occurs in connection with deficient innervation. In paralysed limbs it is not uncommon to meet with atonic ulcers which are painless, quite superficial and often multiple. They have as a rule imperfect granulations upon the surface, and they most commonly occur about the phalanges of the fingers and toes. They are also, however, found on the sole of the foot, and in this situation they are generally ascribed to pressure, and assume more the appearances characteristic of pressure ulcers.

In connection with these ulcers due to pressure upon a paralysed part, the so-called *perforating ulcer of the foot* deserves special notice. It occurs on parts exposed to marked pressure, and is chiefly met with beneath the heads of the metatarsal bones, more especially that of the great toe. It is generally seen in men over 40 who have much standing or walking, and it is not necessarily connected directly with any actual paralytic condition of the limb, but is supposed to result from a condition of peripheral neuritis. The affection commences as a callosity, followed by inflammation of the skin underneath, and a sore forms, resembling at first in all respects an ordinary pressure ulcer. The ulcer extends in depth, becomes more or less funnel-shaped, and rapidly penetrates as far as the bone. The latter may then become the seat of a rarefying osteitis, and may be entirely destroyed opposite the ulcer, which continues to increase in depth until ultimately the dorsum of the foot is reached and a complete perforation is established. When the ball of the toe is the seat of the affection, the metatarso-phalangeal joint is often opened and destroyed. The base of the ulcer is generally covered with reddish warty granulations, the skin is very foul, and the cavity of the ulcer is filled up by a dense mass of epidermis, which undergoes foul decomposition. In some cases the epidermis spreads down the sides of the ulcer, and in many there is marked proliferation of it around the margins of the sore.

(11) In certain **constitutional states**, such as diabetes, ulcers may form. In diabetes, inflammation or ulceration may follow the slightest scratch or cut, and the chief characteristics of a diabetic ulcer are its rapid spread, the presence of considerable inflammation around it, and often sloughing of the tissues. The endarteritis which occurs in diabetes and the special liability of the tissues in that affection to septic infection, have probably much to do with the rapidity of spread and the inflammatory condition of diabetic ulcers.

DANGERS OF ULCERS.—Before dealing with the treatment of ulcers, it may be pointed out that their rapid and permanent cure is a matter of great importance, because not only is a patient afflicted with an ulcer more or less incapacitated from work, but he is liable to various accidents which may permanently cripple him or even lead to his death. For example, where ulcers are situated over muscular parts, the muscles may become so matted together that the movements of the limb are much interfered with. This is more especially the case if the ulcer lies over tendons; the tendon and tendon-sheath may then become adherent to one another and to the surrounding parts. Perhaps the most common disabilities resulting from ulceration are due to the contraction which goes on during the efforts at healing. When an ulcer is situated over a joint, for example, the healing process may lead to so much contraction as to permanently fix the joint in a faulty (usually a flexed) position. Again, when an ulcer completely surrounds the leg, the contraction may be such as to constrict the vessels coming from the parts below, and so cause great and permanent œdema and often complete uselessness of the foot. A further risk of an ulcer is that the veins in its vicinity are apt to become inflamed, and an extensive phlebitis, simple or septic, may result. A patient with an open ulcer is subject to all the ordinary septic diseases, more especially erysipelas. And, lastly, it may be pointed out that, where an ulcer has existed a long time, epithelioma not infrequently develops from it, and the patient may die of this cancerous growth.

TREATMENT.—In order to promote the healing process, various **principles** must be attended to. In the first place, it is essential for rapid healing that the level of the sore should be nearly, if not quite, the same as that of the surrounding parts; secondly, its margins should be moveable, in order to permit of contraction; and finally, the granulations on the surface should be healthy. There are, therefore, three **practical points** to attend to in the treatment of ulcers. (1) To remove the various causes which are keeping up the ulceration, the most important of which have already been mentioned; (2) to improve the condition of the surface and margins of the ulcer; (3) to promote healing in every possible way, and to provide for the formation of as sound a scar as can be obtained.

Remove cause.—The first essential, then, in the treatment of all ulcers, is to seek out the cause and remove it. These causes have been sufficiently dealt with in the foregoing paragraphs, and nothing further need be said about them here.

Rest.—In all cases rest is absolutely necessary. As has already been said, movement tends to keep up the ulceration indefinitely, and consequently the patient must be absolutely prohibited from walking about, and, if necessary, the movements of the neighbouring joints must be prevented by the application of suitable splints. If splints are employed, they should be so arranged that the limb will be in the position most

serviceable to the patient if there be any subsequent stiffness either of joints or muscles. For example, in the case of the leg, on which ulcers are most frequently met with, it is well to apply outside and inside lateral splints which grasp the leg, the knee, and the foot, and fix the ankle-joint so that the foot is at right angles to the leg.

Favour the venous return.—Another principle of the greatest importance is to favour the return circulation. The great danger of venous obstruction has already been insisted upon. It may lead to the transformation of a simple or varicose ulcer into a callous one, and the ulcer will refuse to heal so long as no provision is made for the proper return of blood from the affected area. This indication may be carried out in various ways, but by far the most efficient method is to place the part at a higher level than the heart. Hence, in the case of ulcers of the leg, the patient should be put to bed, the limb elevated on a pillow, the knee and ankle-joints fixed, and the patient not allowed to get up for any purpose whatever till cicatrization is complete. Any relaxation of this rule will not only delay the healing of the ulcer, but may lead to an extension of the ulceration. If the part be elevated, the venous return is greatly favoured, and, even without any other treatment, the exudation which has been poured out is rapidly absorbed. As a result, the pressure upon the arterioles going to the surface of the uleer is removed, and a plentiful flow of arterial blood is again supplied to it. Thus rest and the elevated position not only favour the return of blood from the part, but also the flow of blood to it.

Promote the absorption of the exudation.—Not only should the return of blood be favoured, but measures should also be taken to get rid of the exudation, which presses on and interferes with the circulation in the part. The elevated position and rest in bed are of themselves no doubt sufficient to do this; but if time be an object, various measures may be taken to accelerate the absorption of the exudation. Of these, one of the best is *massage*. Where massage is employed with a view of getting rid of the thickening around an ulcer, it should at first be applied to the parts above the ulcer, and later on, as the skin gets softer in that region, the area subjected to the massage may be increased downwards. If the massage were at first applied to the part below the ulcer, the absorption would not be satisfactory, owing to the presence of the exudation above.

Another way in whieh the exudation may be got rid of is by *pressure*, and this plan is especially useful where patients will not lie up. Pressure may be applied in two ways; either by strapping, or by elastic bandages. The older plan was by the use of *strapping*, but it is not so good as elastic pressure. In employing strapping, strips of adhesive plaster are applied fairly tightly around the ulcer and the parts in its vicinity. These strips should be about an inch to an inch and a quarter in breadth, and rather more than the circumference of the limb in length. They are

applied from below upwards, the centre of each strip being applied at the point opposite the centre of the ulcer, so that as the two ends are brought together over the limb they pull together the edges of the ulcer (see Fig. 11). If the strips are applied with the centre over the ulcer, the reverse will be the case; when they are pulled tight the edges of the ulcer will be separated. The strips should overlap each other for about two-thirds of their breadth, so that only about a third of each is exposed. In this way, by a series of strips of adhesive plaster applied from below upwards, the whole region of the ulcer, as well as the thickened tissues above and below, are firmly supported and pressed upon. Before applying the strapping the whole limb should be shaved, as otherwise a great deal of annoyance is caused to the patient when it is peeled off.

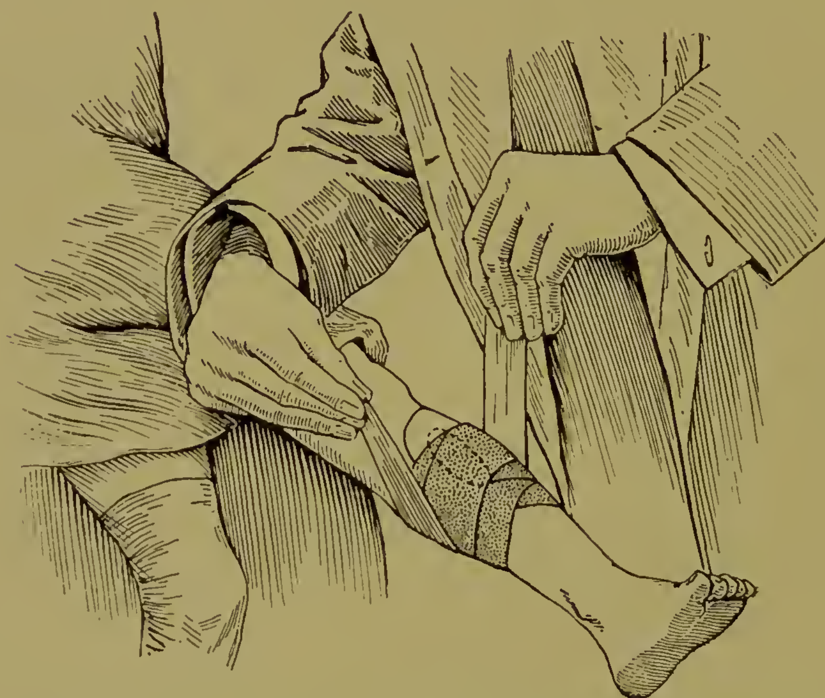

FIG. 11.—STRAPPING AN ULCER. To show how the plaster should be applied in order to bring the edges of the ulcer together as much as possible. The dotted line indicates the extent of the ulcer (over which a dressing is applied).

One great objection to strapping is that the discharge from the ulcer is confined beneath it, and there undergoes decomposition, with the result that fresh ulceration occurs from the presence of this chemically irritating material. Of course, at the present time, one would naturally disinfect the ulcer before applying the strapping, and then place over its surface an antiseptic dressing, such as boracic lint, so as to absorb the fluids and prevent their decomposition. If this be not done it will be necessary to cut away the strapping at the lower part, so as to allow the discharge to escape, a procedure which necessarily weakens it. The strapping ought to be renewed every day or two. It is well to renew it daily if the discharge is at all profuse.

At the present time strapping is generally given up in favour of the *elastic bandage*, that known as Martin's being the most suitable form. Martin's bandage is a thin sheet of pure rubber, cut into strips about three inches wide and of varying lengths; this is wound around the limb, commencing at the ball of the toes and extending up as far as the knee. The best form is that containing a number of perforations to permit of evaporation; otherwise the perspiration accumulates under the bandage, and is apt to set up a dermatitis. The bandage is used both for those who can and those who cannot lie up; when used by the latter, it should be applied in the morning before the patient gets out of bed, and should be put on loosely, being simply rolled spirally around the limb. The rubber should not be stretched when applied, for one cannot gauge the amount of pressure exerted, and as the limb swells when the patient commences to walk about, the bandage may be found unbearably tight. If put on loosely, the œdema which occurs on walking distends the bandage and puts it on the stretch, and in the course of an hour or two it provides a fairly satisfactory amount of support. The bandage should be removed when the patient goes to bed, thoroughly washed and hung up to dry; it is a mistake to wear it during the night. When first introduced, the rubber bandage was applied direct to the surface of the sore without any dressing, but, if this be done, the discharge decomposes beneath the bandage and prevents healing. Hence the ulcer should be first disinfected and then a suitable dressing—to be mentioned immediately—applied beneath the bandage, an important point with regard to the dressing being to avoid a greasy application, as otherwise the rubber will be spoilt.

Another method of getting rid of the exudation, generally employed in the treatment of callous ulcer, may be here referred to, namely, the application of *blisters*. When a blister is applied to the skin, more blood is sent to the part and the lymph flow is increased; and if a blister be applied around a callous ulcer (the limb, of course, being kept at rest and in the elevated position), it is remarkable how quickly the callous condition disappears, and how soon the edges become soft and in a condition favourable for healing.

The essential point in the use of a blister for ulcers is that it should not be applied directly over the raw surface, otherwise the cantharides is apt to be absorbed, and may lead to serious irritation of the kidneys. This must especially be borne in mind in cases of callous ulcer, for many of the patients suffering from this affection are the subjects of Bright's disease. Hence, if emplast. lyttæ is to be used, a part corresponding to the raw surface of the ulcer should be cut away and the blister raised round the margin only. For the method of application of blisters, see p. 18. Usually one blister will suffice, and it will be found that by the time the blistered surface has healed the callous condition of the ulcer has disappeared, and its edges are in a satisfactory condition.

Avoidance of Irritation.—Another point which is common to the treatment of all ulcers is to get rid of any cause of irritation to the surface of the sore. These causes of irritation are either mechanical, such as that caused by dressings applied directly to the surface of the sore, or chemical, such as unsuitable lotions or decomposing discharges: of these the chemical causes are more frequently met with. In order to avoid *mechanical irritation*, the dressing, whether it be gauze or boracic lint, should not be applied directly to the surface of the sore, either oiled silk protective or an antiseptic ointment of some kind being interposed.

A most important point in the treatment of ulcers is the avoidance of the *chemically disturbing causes*: these may be either lotions or decomposing discharges. The lotions used must be non-irritating. They should of course be antiseptic, but the more irritating antiseptics should not be selected. It is too much the practice at the present time to dress ulcers with carbolic lotion, and no more unsuitable application for a healing ulcer could well be employed. The best lotions will be described immediately; in the meantime it must be pointed out that it is most essential to get rid of the chemical irritation from decomposing discharges.

The presence of decomposing discharge on the surface of an ulcer interferes very materially with the healing process, and it is therefore one of the most important points at the commencement of the treatment to remedy, as far as possible, the septic condition of the sore.

Disinfection of the Ulcer.—In order to do this, the following is the method of procedure that we recommend. In the first place the skin, for a considerable area around the ulcer, should be thoroughly disinfected. To disinfect the surface of the ulcer alone and leave the skin septic would simply mean that in the course of a few days the surface would again become foul. Therefore the skin should be thoroughly washed with soap and water and all the hairs shaved off: turpentine is then applied to dissolve the fat, and this is subsequently removed by soap and lotion. The best lotion is a 1-20 watery solution of carbolic acid, containing in solution one five-hundredth part of corrosive sublimate; this we shall speak of hereafter as "strong mixture." The part is thoroughly washed with soap and this mixture, and then well scrubbed with a nail brush dipped in the mixture, and after this is done the strong mixture may be removed from the skin by washing it with a 1-2000 watery solution of corrosive sublimate. As regards the surface of the ulcer, it is not always an easy matter to completely disinfect it at one sitting, but what seems to be the best plan is to swab it thoroughly over with *undiluted carbolic acid*. A small piece of sponge is dipped in liquefied carbolic acid, thoroughly rubbed over the whole surface of the granulations and sides of the ulcer and allowed to act for some minutes. This no doubt destroys the granulations; but these are usually unhealthy, and of no use for the healing process. Apart from this, healing will not occur until the surrounding parts have also

become healthy, and no time is lost even if the granulations be completely destroyed. The carbolic acid causes a good deal of pain at the time, but this passes off in a minute or two, for the acid is a local anæsthetic, and the disinfection is more thoroughly carried out in this way than in any other. Where the granulations are prominent, or soft and œdematous, it is well to scrape them away with a sharp spoon; if the ulcer be large a general anæsthetic is necessary.

Other methods of purifying the ulcer have been employed. Lord Lister used to apply a solution of *chloride of zinc* (40 grains to the ounce of water). This however is much more painful than the application of the undiluted carbolic acid, the pain lasting for hours, while the method does not seem to be so efficient.

In cases where one does not wish to employ undiluted carbolic acid, disinfection of the sore may be obtained by packing the surface with lint dipped in 1 *to* 5 *carbolic oil*; if this be changed twice a day, the foul condition will usually be got rid of in the course of two or three days. Care must be taken that the oil is only applied to the surface of the ulcer; if applied to the skin it may produce much irritation.

First dressing after disinfection.—After the disinfection has been carried out a suitable dressing must be applied, and the best to employ at first is cyanide gauze and salicylic wool, as used in the treatment of wounds (see Chap. VIII.). The cyanide gauze should be soaked in 1-4000 sublimate solution and applied directly to the surface of the ulcer, and the salicylic wool put on outside. In some cases, where there is a doubt as to the completeness of the disinfection, it is well to pack the recesses of the ulcer with small pieces of cyanide gauze which have been lightly squeezed out of 1-2000 sublimate solution.

Boracic lint and protective dressing.—After two or three days, when the asepsis of the part is assured, and the tissues are getting into a more healthy condition, the use of gauze should be given up, and dressings and lotions employed which are of a non-irritating character. The best lotion is a saturated watery solution of boracic acid, and for a general dressing the best is the protective and boracic lint dressing introduced by Lord Lister. In this method the surface of the ulcer is washed with boracic lotion, and a piece of protective (oiled silk covered with a layer of dextrine), is dipped first in carbolic lotion (1-20), and then in boracic lotion to wash away the acid, and applied over the wound. The protective should be slightly larger than the sore, so as to overlap it in all directions, but ought not to extend too far, as otherwise sepsis may spread in beneath it. Outside this protective one or more pieces of boracic lint wrung out of boracic lotion are wrapped around the limb, overlapping the protective to a considerable extent in all directions. This dressing should be changed every day, at any rate for the first few days; and every second or third day the skin around should be washed with carbolic lotion (1 to 20), care being taken that it does not run on to the sore. Once a week at

least the limb should be shaved. If there be much discharge it is well to cut several holes in the centre of the protective so as to allow of drainage into the lint.

Wet boracic dressing.—Where the ulcers are painful, or where there are sloughs on the surface, it is well to apply wet boracic lint without any protective, the lint being used in the same way as a water dressing. The boracic lint soaked in warm boracic lotion is applied over the ulcer so as to extend for a little distance beyond it, and outside this, overlapping in all directions, is fastened a piece of mackintosh, oiled silk, or gutta-percha tissue, previously disinfected by immersion in carbolic lotion. This wet boracic dressing or boracic poultice, as it is sometimes called, should be changed twice a day, but should not be continued after the irritable condition of the sore has ceased, or after the sloughs have separated. If used too long, the granulations become œdematous and a form of weak ulcer is thus established.

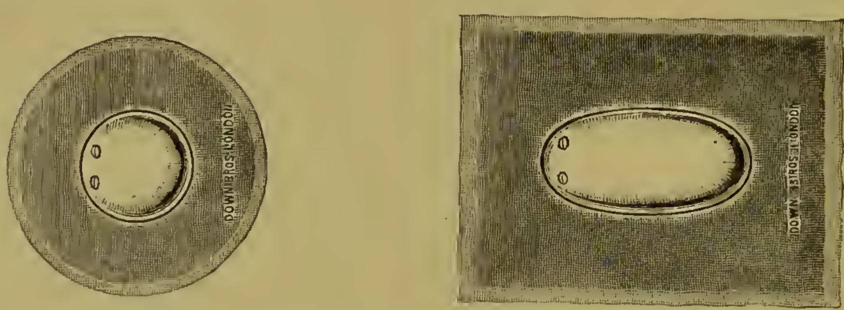

Fig. 12.—Celluloid Wound Shields. The shield is inserted in the centre of a sheet of adhesive plaster, by means of which it is applied to the limb. In the figures two holes are represented in each shield; these are to permit of evaporation. If it be desired to keep the surface of the ulcer quite moist, non-perforated shields may be used.

Boracic ointment.—Another method of dressing that is especially useful where the ulcers are healing rapidly, is the application of various ointments. Of course these must be antiseptic; zinc ointment, which is commonly employed, being, on account of its septicity, a very objectionable dressing for a wound. The best is either unguentum boracis or unguentum eucalypti. The boracic ointment of the Pharmacopœia will however be found to be too strong to permit rapid healing, and, in most cases, one of a quarter its strength is the most suitable. This should be spread on muslin or butter-cloth, in a thin even layer, no portion of the surface being left uncovered by the ointment, and before application it is well to dip it in the boracic solution. Outside the ointment a piece of boracic lint is applied and the whole secured by a bandage.

Cases are sometimes met with where the surface of the sore is extremely délicate and seems to resent the presence of any application, however unirritating it may be. As long as there is anything in contact with it, cicatrization will not take place. Under these circumstances, the best plan is to dispense entirely with dressings and merely to place over the ulcer some

contrivance that will prevent anything coming into contact with its surface. This may be accomplished by fixing over it a perforated *celluloid shield* (see Fig. 12) of suitable size and shape, leaving the granulating surface bare. The shield should be removed two or three times daily, and the raw surface washed with boracic lotion to remove any discharge. The limb should of course be fixed in the elevated position, and the method of disinfection of the surrounding skin recommended above should be carried out before the shield is applied. If there is much tendency to the formation of crusts from the drying of the discharge, it is well to apply a moist dressing outside the shield to prevent evaporation. A piece of cyanide gauze, soaked in boracic lotion and covered with mackintosh, applied over and around a celluloid shield of suitable size and shape, or a *wire cage*, moulded to fit the limb, will usually suffice, the limb being suspended in a cradle.

Skin-grafting to obtain a sound scar.—A further object in the treatment of all ulcers is to obtain a scar that is as sound as possible. In the case of ulcers affecting the lower extremity, especially in elderly people, the scar obtained when the ulcer is allowed to heal of itself is weak, and readily breaks down if the patient does much standing or walking. The result is that every now and then the patient must give up his work in order to get the ulcer re-healed, or must be content to employ means which merely prevent the extension of the ulcer, and only relieve him of some of his discomfort. Where the best possible scar is desired, and where it is important to avoid any great contraction, it is necessary to adopt one of the methods of skin-grafting. There are three plans by which the rapid healing of a sore may be brought about: Reverdin's epidermis grafting, Thiersch's skin-grafting, and the use of the whole thickness of the skin; of these the best in our opinion is that employed by Thiersch.

In **Reverdin's method** small thin portions of the superficial layer of the skin are snipped off by curved scissors. Pieces about the size of a hemp seed are planted on the surface of the granulations at short distances from each other; epidermic growth occurs from each of these little points, and the result is that numerous small islands of epithelium form over the surface of the sore. If the grafts are close enough together and the other conditions of healing are favourable, these islands of epidermic growth soon coalesce, and in this way rapid cicatrization is obtained. It is necessary that these grafts should not be too far apart, because, as a rule, they have only a limited power of reproduction. Usually each graft gives rise to an island of epidermis about the size of a sixpence, and then growth seems to come to a standstill. The result of this method of epidermic grafting is that rapid healing is obtained in many cases, more especially in burns and sores on the trunk, where the skin is freely moveable over the deeper parts. Further, the contraction of the subsequent cicatrix is considerably diminished, because less granulation tissue is formed than if the sore has to heal altogether from the margin, and the amount

of contraction depends entirely on the amount of young granulation tissue produced. Nevertheless, a considerable amount of contraction will inevitably occur where healing has been obtained in this way, and the resulting scar is not materially stronger than that obtained by permitting the sore to heal from the edge.

With a view of obtaining a sounder scar, much more extensive and thicker portions of the skin must be taken, and the grafts must be applied close together. There are two ways of doing this: either by using the whole thickness of the skin, or by employing Thiersch's method, in which about half the thickness of the skin is shaved off. We need not describe the procedure where the whole thickness of the skin is employed, partly because the results are not satisfactory, and partly because all the conditions for which it was introduced are far better fulfilled by Thiersch's method.

Thiersch's method.—In employing Thiersch's method, the skin which is to be used for the grafting must first be thoroughly disinfected in the usual manner, namely, by turpentine, soap and strong mixture, and it must also be carefully shaved. The presence of hairs on the grafts seems to materially interfere with their union. The skin of the front of the thigh or the flexor surface of the fore-arm is usually employed for the purpose.

Preparation of Ulcer.—(*a*) *Preliminary.*—The sore itself must also be prepared beforehand. It is of no use to graft a sore which is actually ulcerating; it must be brought into a healthy condition, and healing must have commenced before grafting is likely to be successful. The best criterion that healing is taking place is the presence, at the edges, of the dry red line which indicates recently formed epithelium. Some surgeons wait for a considerably longer time before grafting, in order to get a firm layer of granulations, but our experience is that, as soon as healing begins around the edge, the sore may be safely grafted upon. A second essential is that the sore shall be aseptic. If it is suppurating, and the discharges are septic, the graft—which is after all merely a piece of dying tissue—will become impregnated with decomposing pus, and will rapidly become loosened, die, and undergo decomposition. The methods of rendering the ulcer aseptic have already been described (see p. 46).

Fig. 13.—Thiersch's Method of Skin-grafting. *Ulcer prepared for grafting.* The newly healed edge has been cut away, and the surface has been scraped till all the granulations have been removed and the firmer layer of newly formed fibrous tissue exposed.

(*b*) *Operative.*—With a sore that is aseptic and beginning to heal, the following is the method of procedure. The patient having been put under an anæsthetic, the granulations over the whole surface of the ulcer are evenly scraped away, taking care, however, only to remove the soft

layer of granulations and not to go through the deeper one of newly formed fibrous tissue into the fat. A surface is thus left which is smooth, highly vascular, and firm, and consists of the deeper layers of granulation tissue which have already become organized into fibrous tissue (see Fig. 13). In ulcers on the lower extremity, it is also of the greatest importance to remove those portions of the edge which have already become covered with new epithelium. One is tempted to limit the skin-grafting to the parts actually unhealed, but if this be done the result will, as a rule, be very disappointing, for, while the part that has been grafted remains perfectly sound, the margin where spontaneous healing had occurred is very likely to break

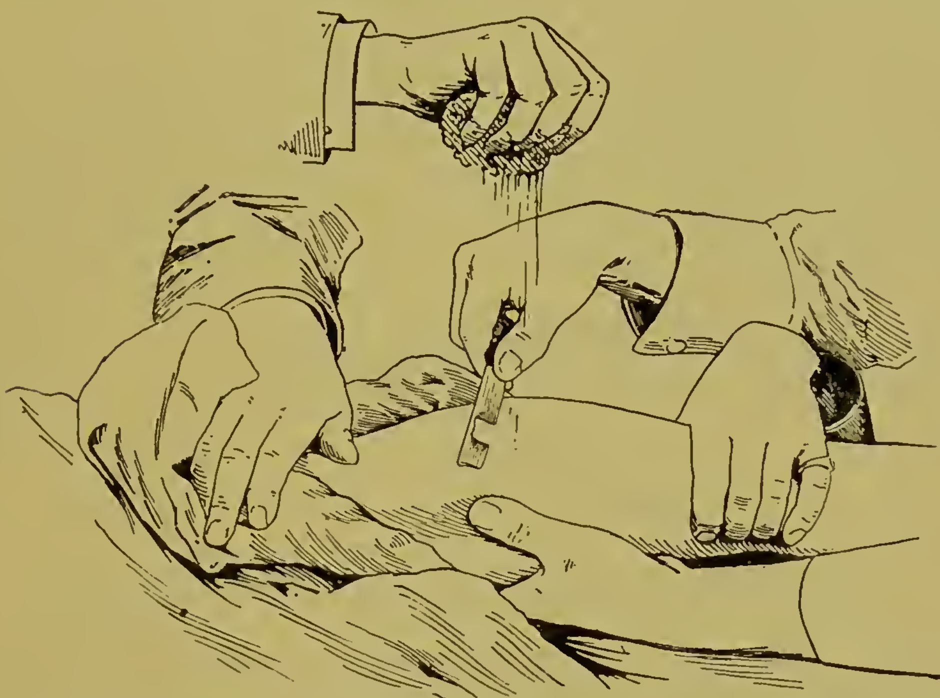

FIG. 14.—THIERSCH'S METHOD OF SKIN-GRAFTING. *Cutting the grafts.* To show how the parts are steadied while the grafts are being cut.

down, and thus a narrow line of ulceration appears later on at the site of the edge of the ulcer. Having then removed the layer of granulations in the manner described, and cut away the newly healed edge of the ulcer (as shown in Fig. 13), the next thing is to arrest the bleeding completely before applying the grafts. This is best done by pressure, but, if pressure be applied directly to the sore either by sponges or dressings, it will be found that the bleeding begins again when they are removed, because they stick to the raw surface. The best plan is to interpose a piece of protective (see p. 47), which prevents adhesion of the sponges to the sore and thus avoids a renewal of the bleeding on removal. Hence, when the scraping and cutting are finished, any spouting vessel is clamped, and a large piece of protective dipped in the 1-2000 sublimate solution is applied over the raw surface. Outside this several sponges are placed, and a bandage

dipped in 1-2000 sublimate solution is firmly bound over them, or, if the sore be small and an assistant available, he may apply the pressure.

Cutting the Grafts.—While the bleeding is being arrested by pressure, the surgeon proceeds to cut his skin-grafts. In Thiersch's method the grafts may be taken from any part of the body, but as a rule they are most conveniently cut from the front of the thigh. The skin having been disinfected (see p. 46), the surgeon grasps the thigh from behind with his left hand, keeping the skin as tense as possible and also making it prominent and flat by pushing the muscles and skin forwards from the bone. This is shown in Fig. 14. The skin is further put on the stretch vertically by an assistant who pulls it upwards at the groin and downwards at the knee. The razor (shown in Fig. 15), which should have a very broad blade, is dipped in boracic lotion and is constantly kept wet by this solution whilst the grafts are being cut, just as in making microscopical sections of fresh tissues. If this irrigation be not maintained, the graft tends to adhere to the razor and may be either partially or wholly cut through before a sufficient length has been obtained. The razor is made to penetrate through about half the thickness of the skin, and then, by a lateral

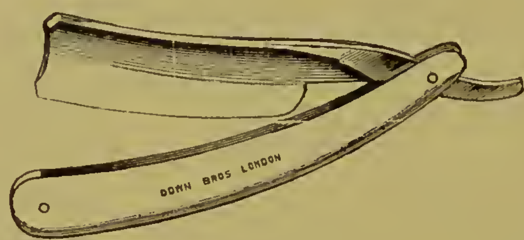

FIG. 15.—THIERSCH'S METHOD OF SKIN-GRAFTING. *Special razor for cutting grafts.* The handle is metal and the blade is short and very wide. In using it, it will be found most convenient to grasp it with the blade and the handle in the same straight line (see Fig. 14).

sawing motion, the grafts are cut as broad and as long as possible. After a little practice it is easy to cut grafts about two inches in breadth, and six or seven in length. If one graft is not sufficient, it is best simply to slide it off the razor and leave it lying on the bleeding surface; in this way it is kept warm and moist. Some surgeons put the graft into warm saturated boracic lotion, and it is then said to spread out more easily afterwards, but by the former plan, the tissues lie in their own juices and the cells are more likely to retain their full activity.

Application of Grafts.—When a sufficient number of grafts have been cut, the bandage, sponges, and protective are removed from the wound and, if the bleeding has quite stopped, as is generally the case, the grafts are applied to its surface. The latter usually has a thin layer of blood clot upon it, and this should be gently wiped away. Each graft is lifted with forceps or the fingers, and placed on the sore with the cut surface downwards, and then, by means of a couple of probes, the folds of the graft are carefully undone, and it is stretched evenly over the surface (see Fig. 16). The grafts should overlap the edges of the skin and also each

other, so that no part of the raw surface is left exposed, for granulations always spring up on the uncovered parts, and are apt to eat away the grafts in their vicinity; furthermore a thin scar, which may subsequently break down, is left at these points. The graft is always thinner at the edge than at the centre, and it is these thin edges which overlap each other or the edge of the ulcer; there is no real sloughing of these overlapping edges.

Dressing.—In spreading out the graft, it will be found that air bubbles collect beneath it, and also that some amount of oozing goes on, and the bubbles and clot may prevent complete adhesion of the graft. Hence the next procedure is to get rid of them by pressure. If that be attempted

FIG. 16.—THIERSCH'S METHOD OF SKIN-GRAFTING. *Spreading the grafts out upon the raw surface.* The overlapping of the grafts is also shown.

by means of sponges or the hands, the graft is apt to be displaced. The following is the best plan: strips of protective about an inch in breadth, and long enough to overlap the edges of the wound, purified in 1-20 carbolic lotion and subsequently rinsed in boracic lotion, are applied firmly over the grafted surface, beginning at the lower part. Each strip should overlap the one below, just as in the case of strapping, and they should extend well on to the skin at each end (see Fig. 17). If each strip as it is put on be grasped by the two ends and firmly pressed down on the limb, the pressure thus applied suffices both to expel the air-bubbles and blood, and also to arrest further capillary oozing. The whole surface of the skin-grafts being thus covered, ordinary cyanide gauze wrung out of 1-4000 sublimate solution is applied, with salicylic wool outside it. The limb should afterwards be placed upon a splint, or at any rate so fixed that movement cannot occur during the progress of healing.

The place from which the grafts have been taken may also be dressed with the protective and gauze dressing, which need not be disturbed for

ten days or a fortnight. At the end of that time the whole surface will usually be healed, unless the razor has somewhere gone a little deeper than is necessary. If healing be not quite complete, weak boracic ointment may be applied. The limb from which the grafts are taken should always if possible be the same as that on which is the ulcer requiring grafting; for example, when the ulcer is on the leg, the grafts should be taken from the thigh of the same side. Unless this be done, a second splint will be required to fix the limb from which the grafts have been taken, until healing is complete.

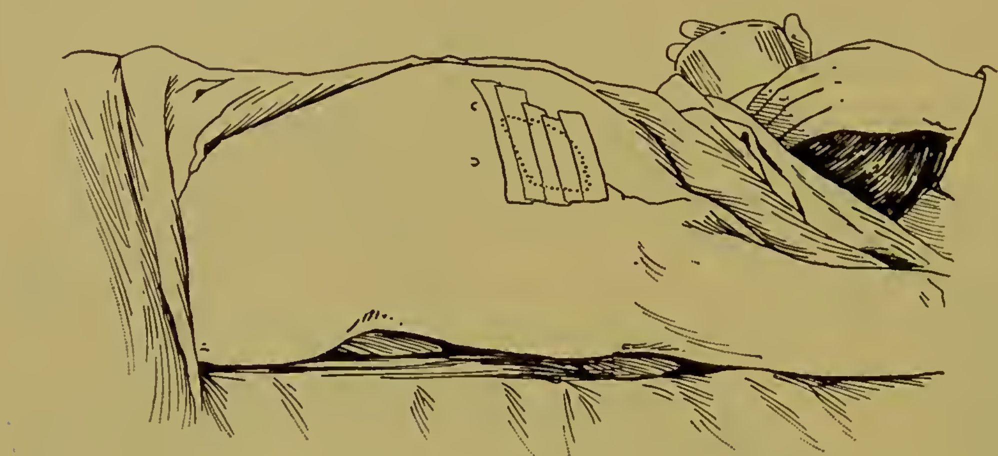

Fig. 17.—Thiersch's Method of Skin-grafting. *Application of protective.* The wound is represented by the dotted line, and the strips of protective overlapping one another and the edges of the wound are shown in position.

Changing first Dressing.—The dressing should be left on the grafted surface for about five days; in some cases it may even be left for a week. If the wound be aseptic, no suppuration or decomposition takes place beneath it. While removing the dressing, it should be thoroughly soaked with a 1-2000 sublimate solution, for the protective may stick at the edge and adhere to a graft, which may thus be peeled off unless great care be taken. The parts should be gently cleansed with a 1-2000 sublimate solution, and it is best to re-apply the protective and gauze dressing for about another week. At the end of that time the grafts are fairly firmly adherent, and then an antiseptic ointment—preferably the quarter-strength boracic—is the best application.

After-treatment.—It will be found that, even at the first dressing, the grafts present a pink colour and are adherent to the deeper surface, though they are still readily detached. In the course of about a week the old epidermis peels off, but no raw surface is left. Later on there is a great tendency to the formation of new epithelium, cornification and drying up, and it is in avoiding the latter condition that ointments are so useful. In fact, till the scar is absolutely sound, it is well to keep the surface covered with some greasy application, the best being the quarter-strength boracic ointment.

Time required for cure.—A very important point to decide is when the patient may be allowed to walk about after an ulcer of the leg has been skin-grafted. If he begins too soon, the grafts will almost certainly become detached. That this will be so, is evident from a consideration of the mode in which the adhesion of the grafts takes place. At first they adhere to the surface of the sore simply by means of the effused and coagulated lymph. Cells very rapidly spread into this lymph, and, in the course of two or three days, the space between the graft and the raw surface is occupied by a mass of young cells. In this tissue young blood vessels develop, and penetrate into the grafts, whilst, at the same time, the cells of the grafts grow and assist in the development of the young tissue and of the blood-vessels. Thus the graft becomes vascularized, but for a considerable time the tissue between it and the surface of the sore contains many young blood-vessels with delicate walls, and therefore, if the patient stands erect and allows the pressure of the column of blood to tell on these vessels, they rupture, and bleeding occurs beneath the graft and leads to its detachment. It requires a long time before the graft is firmly incorporated with the tissue beneath, by the development of elastic fibres; indeed, it may be reckoned that this union is not complete until from three to six months have elapsed. Certainly up to three months the graft will in all probability be destroyed if the patient walks about. Hence, unless that time can be devoted to the treatment, it is not worth while employing skin-grafting for ulcers of the lower limbs. By this, however, it is not implied that it is necessary to keep the patient in bed for the whole time, but merely that the foot must not be allowed to hang down, nor must any weight be borne upon it. At the end of about six weeks the patient may be allowed to get up and lie on a sofa or sit up with the leg on another chair, but it must not be permitted to hang down. At the end of about three months he may be allowed to get about, but in order to prevent the detachment of the grafts, he should be fitted with a knee rest and peg on which he walks, the leg projecting out behind him. If possible he should not put his foot to the ground till five or six months have elapsed.

Of course, in cases of sores on other parts of the body, where the erect posture does not cause congestion of the parts, the patient may be allowed to walk about almost from the first, certainly after the first three weeks.

Results.—The scar which results after skin-grafting performed in this manner is of a highly satisfactory character, and by its means ulcers which have been intractable for years may be firmly and satisfactorily closed, with very little tendency to break down subsequently; but in order to obtain that result, the period of rest prescribed must be carefully attended to.

Treatment where Patients cannot lie up.—The surgeon has also to treat ulcers in the Out-patient department of Hospitals, where the measures above referred to cannot be employed, as the patient is unable to afford

the necessary time, and the question then arises, what is best to be done? In the first place, one cannot expect to cure the ulcer, though in some rare cases the ulcer does heal; in the majority, however, even though it may be somewhat improved, it remains open. Nevertheless a good deal may be done to alleviate the patient's troubles and to prevent the further spread of the sore. In treating out-patients it is impossible to get rid of the dependent position of the limb and the bad results it produces, but these may be mitigated by giving as much support to the circulation as possible; the septic condition of the wound can also be got rid of.

These, then, are the two points which are to be aimed at in the "ambulatory" treatment of ulcers of the leg—support of the circulation and asepsis of the sore. The asepsis of the sore is carried out on the lines already described (see p. 46), and the method need not be repeated here. As to the support of the circulation, the most popular method is by the use of Martin's rubber bandage, the mode of application of which has been already detailed (see p. 45). Still better than Martin's rubber bandage, and what we would advise in the first instance, is the method introduced by Unna, and known as *Unna's bandage.* This is a bandage stiffened with gelatine, and its advantages are that the patient cannot meddle with the sore, and that it gives a uniform elastic support without unnecessary pressure; it is applied in various ways.

The method we prefer is as follows. In the first place, the sore and skin around are thoroughly disinfected, and a dressing of protective and boracic lint applied. Later on weak boracic ointment may be substituted, or protective and gauze may be used for a few days. After the sore has been properly purified, a mixture consisting of 40 parts of water, 40 of glycerine, 10 of gelatine, and some oxide of zinc to make it stiffer, is applied to the outside of the dressing. This material becomes solid at the ordinary temperature, but is readily liquefied by gentle heat. The liquefied material is rubbed over the outside of the dressing, and a double-headed bandage is put on, beginning over the centre of the ulcer, one roll going downwards towards the toes and the other upwards towards the knee. This bandage is applied smoothly and not tightly, the melted mixture is then rubbed into it, and before it sets another bandage dipped in hot water is applied over it. This arrangement dries in a very short time and forms a firm, elastic, and at the same time not too heavy support to the limb, and thus some of the disadvantages of other dressings, more especially the irregularity of the pressure which often occurs in a self-applied Martin's bandage, are avoided. If possible, Unna's bandage should be put on early in the day before the leg has swollen from walking about. The dressing should be changed according to the amount of discharge present; usually at first every other day, but, as the discharge diminishes, at less frequent intervals. It is readily removed by putting the leg in a tub of warm water so as to melt the gelatine, and the bandages can then be unwound quite easily. In cases where the ulcer has healed the

parts should be supported for some time by Unna's bandage; massage should also be used, more especially if the scar be hard and fixed and the muscles atrophied. The legs should be frequently immersed in a warm bath and lanoline rubbed into the skin so as to soften the epidermis.

Special points in the treatment of the various forms of Ulcer.—The foregoing remarks as to treatment apply to all ulcers, but it will now be well to mention certain points peculiar to the treatment of the individual forms.

(1) *Simple Ulcer.*—The simple ulcer is one that is prevented from healing by various local causes not usually of a serious character. The chief of these are standing and walking, especially if varicose veins are present or the patient is advanced in years. If these causes be removed, and the limb placed at rest in a suitable position, the sore will quickly heal. In the treatment of a simple ulcer, then, the patient should be put to bed, the leg elevated on a pillow, and fixed if necessary, and suitable dressings applied to the part. It is well to disinfect the surface of the ulcer (see p. 46), but where the surface is comparatively healthy it is hardly necessary to destroy the granulations by means of pure carbolic acid; in such instances, powdering the sore with iodoform will usually suffice. The best dressing is the quarter-strength boracic ointment, used as described on p. 48, and changed either every day or every alternate day. When the ulcer is large, and especially if the patient be old, skin-grafting (see p. 50) should be employed with a view of obtaining a permanent cure.

(2) *Inflamed Ulcer.*—Here there is not only ulceration but also acute inflammation, and both conditions require treatment. The patient should be put to bed with the leg elevated, and warm antiseptic fomentations applied. The best of these is boracic lint dipped in warm 1-4000 sublimate solution or boracic lotion, applied wet over the ulcer and the skin in the vicinity, and overlapped in all directions by gutta-percha tissue or mackintosh. This dressing should be changed twice a day at least, and oftener if the inflammation be severe or the pain acute. Before doing this it is well to disinfect the surface of the sore by the application of undiluted carbolic acid, and then to powder it with iodoform once or twice a day for a few days. Another important point is local depletion. We have previously mentioned the fact (see p. 39) that where these ulcers are multiple they are separated by bridges of skin, which are much swollen and inflamed, and are prone to become gangrenous. The division of these bridges will often prevent the impending gangrene, and the consequent loss of tissue, while at the same time it allows the escape of exudation and of blood, and so improves the inflammatory condition. Even where these bridges of skin are not present, considerable improvement will be obtained in an ulcer of this kind by making incisions into the inflamed tissues around, the cuts radiating from the centre of the ulcer. When the inflammation has subsided the treatment is that of a healing sore. (Boracic ointment

treatment, see p. 48.) Skin-grafting (see p. 50) will be called for where the ulcer is large.

(3) *Weak Ulcer.*—In the case of a weak ulcer the cause of the weakness (see p. 39) must be sought for and removed. If general anæmia be the cause, it should be treated by iron, best administered in the form of Blaud's capsules, commencing with doses of five grains three times a day. While iron is the best drug to use in ordinary cases of anæmia, some cases, especially of the graver chlorotic form, yield more quickly and satisfactorily to arsenic, and therefore, if the iron does not seem to suit, liquor arsenicalis should be substituted for it, beginning with doses of three minims after food twice a day, and increasing the dose by one minim every third or fourth day up to twelve minims or more. The medicinal treatment must, of course, be accompanied by nourishing diet and good hygienic conditions. Where the cause of the weakness of the ulcer is œdema from heart or kidney disease, treatment suitable to these affections must be employed.

Of local conditions one of the first things that should be looked for is difficulty in the contraction of the sore. This may result from adhesion to the deeper parts, from the hardness of the tissues around the sore, as in the callous ulcer, or from the size of the original sore and the large amount of cicatricial tissue formed during healing, etc. If due simply to the denseness of the scar, apart from exudation into the tissues, lateral incisions through the sound parts beyond will sometimes allow the ulcer to heal. Where the latter is adherent to bone it should be detached, portions of the thickened margin cut away, the surface scraped with a sharp spoon, and skin-grafting employed. In some instances portions of bone have been removed, or joints have been excised to allow of contraction taking place; but this is very rarely necessary, especially since the introduction of Thiersch's method of skin-grafting. In every case of weak ulcer, the part must of course be kept at rest in the elevated position, and the weak granulations should be destroyed. The best way of doing this is to scrape them away and apply undiluted carbolic acid to the raw surface, thus disinfecting the ulcer at the same time.

Where, in a sore which has been rendered aseptic, the granulations become exuberant, they should be clipped off and, after the oozing has stopped, the surface rubbed with nitrate of silver. Should there be excessive growth of the granulations afterwards, they may be kept down by repeated applications of solid nitrate of silver or sulphate of copper made daily, or every other day. Care must be taken not to apply this to the healing edge.

Various stimulant applications are usually advised for weak ulcers, such as solutions of sulphate of zinc (the so-called red lotion),[1] or sulphate of copper in a strength of two grains to the ounce of water. These are

[1] The formula for "Red Lotion" is as follows: Zinci sulphatis, gr. xx; Spiritus Rosmarini; Spiritus Lavandulæ, āā ʒiij; Aquæ ad Oj.

chiefly of use in that form of weak ulcer where the surface is quite inactive and shows few and imperfect granulations. They are useless in the cases with exuberant or œdematous granulations. It is doubtful how far benefit results from these applications, and they are not to be recommended in the ordinary treatment of ulcers, and should only be used in the particular form of weak ulcer to which we have alluded, and which is most often associated with general anæmia. Where the sore is œdematous, the best dressing is weak boracic ointment; the protective and boracic lint tend to increase the œdema by confining the moisture. As soon as any of these ulcers get into a healthy condition, skin-grafting should be employed.

(4) *Irritable Ulcer.*—The intense pain associated with this form of ulcer is best met by cauterising the ulcer thoroughly by means of nitrate of silver, so as to completely destroy the sensitive terminations of the nerve. Treatment on the principles recommended for a simple ulcer should be subsequently carried out. Where quite small, complete excision with immediate skin-grafting is the best treatment for these affections.

(5) *The Phagedenic Ulcer.*—This ulcer requires energetic treatment in order to destroy the infected tissues, and this may be done, after the slough has been scraped away by a sharp spoon or clipped off by scissors, either by means of the actual cautery (see p. 19), by potassa fusa (see p. 20), or by nitric acid. Where nitric acid is used its action should be neutralized, after the lapse of a few minutes, by pouring on the wound a strong solution of ordinary washing soda; this should be done until effervescence, from the liberation of carbonic acid gas, ceases. Of these the actual cautery is the best. It should be heated to white heat, and the parts thoroughly destroyed by it. By means of the cautery, (Paquelin's cautery will also answer the purpose,) one can gauge the amount of destruction done; whereas caustic potash generally destroys more of the tissue than is really necessary; whilst the coagulation of the albumen caused by nitric acid interferes with its action, so that, as a rule, it does not extend sufficiently deep. Subsequent to the application of the escharotic, undiluted carbolic acid should be sponged over the surface, and a dressing of strong carbolic oil (1 to 5), as directed on page 47, should be applied. Here the first object is not to obtain healing, but to eradicate a most dangerous bacterial poison, and one which spreads with intense rapidity.

(6) *Varicose Ulcer* must be treated on the lines already mentioned (see p. 43), namely, by rest in the elevated position, disinfection of the sore, the application of protective and boracic lint dressing, or boracic ointment, and by subsequent skin-grafting. But the patient should not be allowed to go about again till the varicose veins have themselves been treated. As long as the limb is elevated the presence of varicose veins does not delay the healing, but directly the patient begins to walk about they favour in a very marked degree the subsequent breaking down of the ulcer. As, however, under proper conditions, the varicose veins do not interfere with

the healing of the wound, it is well to defer the operation till the ulcer has closed, so as to avoid any risk whatever of sepsis occurring in connection with the operation on the veins. The treatment of varicose veins will subsequently be referred to; it consists essentially in the removal of portions of the prominent veins, especially the points of junction of several of their branches.

(7) *Callous Ulcer.*—Here the obstacle to healing is the callous condition of the surrounding parts, and hence our first effort must be directed to getting rid of this condition. As a matter of fact, if the limb is put at rest, the leg elevated, and the sore rendered aseptic, this callous condition will subside comparatively quickly, and in the course of two or three weeks the sore will present a healthy appearance and the healing process will begin. Where it is desirable to expedite matters, or where the thickening of the tissues does not disappear as quickly as usual, other plans, which have been referred to on page 45, may be employed, and of these the best is the application of a blister, provided always that the kidneys are in a healthy condition. The callous edges having been got rid of, and the sore having assumed a healthy condition, skin-grafting should be employed in the manner already described (see p. 50); and should varicose veins be present, they should be operated on after the wound has healed, but before the patient is allowed to walk about. For the "ambulatory" treatment of callous ulcer, see page 56.

(8) *Pressure Ulcer.*—A pressure ulcer occurring in the centre of a callosity is sometimes very obstinate in healing, and the best treatment is to cut away the callosity which surrounds the ulcer, and to scrape the surface of the latter. In this way a shallow healthy sore is left, which heals comparatively quickly. Of course the sore should be disinfected, and the limb elevated and kept at rest in the usual manner. Where a pressure ulcer occurs in the foot, it is perhaps well to skin-graft it, in order to avoid the thin scar which results from the natural process of healing, and which is very apt to remain tender or break down subsequently; and when the patient first begins to walk about, the boot should be excavated at the part corresponding to the scar, so that pressure does not tell, for a time at any rate, on the seat of the previous ulcer.

(9) *Paralytic Ulcer.*—Here it is often very difficult to obtain healing, and stimulant applications should be employed. In the early stage the cyanide gauze should be applied directly to the raw surface, after the ulcer has been disinfected. The gauze is very useful as a means of inducing granulation. After granulation has occurred the best dressing is perhaps boracic lint soaked in balsam of Peru. This dressing is antiseptic, and at the same time possesses a markedly stimulant action; it should be changed daily. When healing is well in progress the quarter-strength boracic ointment (see p. 48) should be substituted. The position of the limb, rest, the administration of nourishing diet, etc., must of course be attended to. Besides this the application of spirits of wine to the parts around

and the use of massage (see p. 22) and electricity to the whole limb should be had recourse to with the view of improving the nutrition and increasing the circulation. The electric current may be employed in one of two ways. The first and simplest plan consists in covering the whole of the ulcerated area with a layer of gauze or absorbent wool, thoroughly wetted with salt solution or boracic lotion, and applying to this the negative pole of an induction coil, the positive pole being applied to the spinal column. A gentle current of about 5 milliampères should be used at first; if this causes pain it must be diminished. The apparatus should be so arranged that the circuit can be opened and closed about 30 times per minute. The sittings should occupy from 10 to 15 minutes and may be made daily. The strength of the current may be cautiously increased up to 10 or more milliampères, but it should never be strong enough to cause pain. The other method is to immerse the affected limb in a small electrical bath. This may be improvised by using a china basin or wooden tub or trough of suitable size, which is filled with salt solution and in which the affected part is immersed. The electrodes, which should be in the form of flat copper plates connected with the poles of an induction coil, are placed on either side of the limb, the negative being in direct contact with the ulcer. A current sufficiently weak for the patient to bear without discomfort must be employed. This method is more cumbrous than the first and offers no advantages over it.

10. The *Perforating Ulcer of the Foot* is often obstinate under treatment. The limb may be placed on a splint, at rest in the elevated position for a long time, without the slightest attempt at healing occurring. One reason for this is no doubt the tendency of the epithelium to fill up the cavity and decompose there, or else to spread down the edges of the ulcer. The most satisfactory plan in these cases is to excise the edges and sides of the ulcer, cut away the whole of the callosity around, scrape out the bottom of the ulcer until sound tissue is reached and then disinfect the whole surface with undiluted carbolic acid (see p. 46) and dress it antiseptically. Healing will not begin until the cavity of the ulcer has filled up with granulations. Therefore it is well to promote granulation by stuffing the cavity lightly with cyanide gauze which by its irritation greatly favours this occurrence. The gauze should be sprinkled over with iodoform and changed daily. When the granulations have grown nearly up to the level of the surrounding surface some non-irritating dressing such as the quarter-strength boracic ointment (see p. 48) may be substituted for it. In cases where the ulcer is extensive, skin-grafting may with advantage be employed.

(11) Lastly, with regard to the ulcers which are dependent on constitutional conditions, more especially *diabetic ulcers*, the local treatment must be carried out on the same principles, namely, disinfection, position, and careful dressing. Of dressings, boracic fomentations are the best at first, but these ulcers will not do well unless something is done to

improve the constitutional condition. In the case of diabetes, the patient must be put upon the anti-diabetic diet and codeine: these will be referred to more in detail in speaking of diabetic gangrene (see p. 76). In a diabetic patient operations are not satisfactory, and this is the one form of ulcer in which skin-grafting cannot be recommended. The ulcer should be simply allowed to heal if it will, and should be supported afterwards by Unna's bandage, etc., with the object of preventing a recurrence.

CHAPTER IV.

GANGRENE.

DEFINITION.—By gangrene is meant death of macroscopic portions of the tissues, and the term is usually employed only when the portion which dies is extensive, more especially where the whole or part of an extremity is affected. If the portion of gangrenous tissue be small, the dead part is termed a slough, and the process is spoken of as sloughing.

CLASSIFICATION.—In speaking of gangrene two classifications are employed, the one a clinical classification into dry and moist gangrene, the other an etiological one into direct, indirect, and specific gangrene. The use of the latter classification makes the whole subject of treatment more intelligible.

SYMPTOMS.—It will save repetition if we speak first of the terms dry and moist gangrene. **Dry Gangrene** is the form met with when the gangrene occurs so slowly that the fluids of the part have time to dry up. Under these circumstances the dead tissues do not form proper pabulum for the ordinary putrefactive bacteria, and therefore the usual signs of putrefaction are wanting. The part usually has a mouldy rather than a foul odour, and there is not the same amount of septic absorption as in the moist form. The patient is at first comparatively or altogether free from fever and symptoms of septic poisoning, and there is less inflammation in the neighbourhood of the dead part than is the case in the moist variety. The gangrenous part is black, shrivelled up, greasy, and semi-transparent from the breaking down of the fat, so that the tendons and bones can be seen through the skin. At the junction of the dead with the living part there is a faint red blush. In dry gangrene, as a rule, the line of demarcation is imperfect, and after a time fresh gangrene may appear above it. The chief symptom is pain.

Moist Gangrene, on the other hand, is characterized by the rapid putrefaction of the dead part, and the patient soon shows signs of septic absorption. The gangrenous part is generally reddish at first, and ultimately becomes black; bullæ containing dark foul fluid form over it, and it crepitates on pressure from the presence of gas. The soft parts become liquefied and separate from the bone as a dark slimy foul-smelling mass. Around the edge of the gangrene there is marked redness and more

or less rapid formation of a definite line of demarcation. Without going fully into the symptoms, it is self-evident that dry gangrene is much less unfavourable to the patient than the moist form.

TREATMENT—(*a*) **Local.**—The treatment of gangrene depends, to a great extent, on the cause of the particular form, but it will be of advantage to refer here to one or two general principles. It is evident, from what has been said as to the difference in the symptoms in moist and dry gangrene, that the most important point in the treatment, if the gangrenous part be not removed, is to prevent the septic decomposition which will otherwise take place—in other words, to favour the production of the dry form. Hence, if it be suspected that gangrene is about to take place, as, for example, where the circulation in a part does not recover in reasonable time after embolism or ligature of an artery, the skin should be disinfected as thoroughly as possible. The limb is shaved and rubbed with turpentine so as to remove the grease, and then washed with soap and strong mixture (see p. 46). By means of a nail brush the part is thoroughly scrubbed for a considerable time with the strong disinfecting solution, and especial attention should be paid to the nails, which should be cut short; the folds of skin under and about them should be scrubbed with extreme care. Having thoroughly carried out the disinfection, the next procedure is to apply an antiseptic dressing designed to prevent decomposition and at the same time to allow drying of the part. The best is that usually employed for wounds, namely, a large mass of cyanide gauze soaked in a weak antiseptic solution, such as a 1-4000 sublimate solution, outside which is applied a thick layer of salicylic or, better, freshly sterilized wool, taken direct from the sterilizer and on which no dust has settled. It should be borne in mind that the organisms in dust have to be guarded against, as well as the pyogenic and other pathogenic organisms. This dressing permits drying, and it should not be disturbed unless it is wished to ascertain whether death has occurred, or unless discharge comes through. Above all things, the use of ointments should be avoided, because they prevent the evaporation of the fluid, and so keep the gangrenous part moist. The limb should be placed on a water pillow and slightly elevated. Other points in the treatment of gangrene, especially the question of amputation, will be considered in connection with the particular forms of gangrene.

(*b*) **General.**—The general treatment will consist in the administration of strong and easily digested food, such as various extracts of beef, bovril, Valentine's meat juice, lean underdone meat, chicken, game, fish, etc. Stimulants are usually necessary; the best is brandy, or, if there be no diabetes, champagne. Besides these, drugs, more especially opium, must be employed to relieve the pain, and the excretions, in particular the free evacuation of the bowels, must be attended to. The urine should be carefully examined for sugar or albumen, and if either be found the necessary diet and treatment must be adopted.

ETIOLOGICAL CLASSIFICATION.—We may now pass on to the consideration of the etiological classification of gangrene, according to which there are three great varieties, namely, direct, indirect, and specific gangrene. By direct gangrene is meant gangrene of a part which has been directly subjected to an injury, as, for instance, where a cart wheel passes over the foot and the result is that the foot dies. Indirect gangrene is where the gangrene occurs at some distance from the cause, as, for instance, where, after ligature of the femoral artery, the foot becomes gangrenous; and specific gangrene is the variety due to specific organisms, for example, phagedena, acute traumatic gangrene, and the like.

A. Direct Gangrene may be due (1) to crushing of the part, (2) to pressure, (3) to acute inflammation, and (4) to the action of heat or cold.

(1) **Gangrene due to Crushing.**—The most common cause of direct gangrene is severe contusion or crushing, as, for example, where a limb has been run over. In some cases the parts which are directly subjected to injury may lose their vitality at once; in other cases, where septic inflammation occurs subsequently, tissues may die which were not killed outright by the injury itself. Further, we may in these cases have indirect as well as direct gangrene; for example, where the wheel of a heavy cart passes over the leg it may rupture the blood-vessels going to the foot, and so lead to gangrene of the toes and the foot as well as of the tissues at the site of the injury. This form of gangrene is moist, and the constitutional symptoms and local appearances depend on whether or not it has been possible to render the part aseptic immediately after the injury.

Treatment.—In this form of gangrene affecting the extremities, it is not always easy at first to say whether the part be killed or not; hence it is well, when the state of the patient will permit, to wait until it is possible to ascertain the exact extent of the injury. But at the same time, while waiting, means must be taken to prevent or diminish as far as possible the putrefaction of any portion which may die. The parts should therefore be disinfected thoroughly in the manner just described (see p. 64), and a dressing applied and left on for twenty-four or forty-eight hours, till it is seen how much tissue is going to die. An additional advantage of delay is that the patient may recover from the shock of the accident before he is subjected to the shock of the amputation; one of the great dangers of primary amputation is the addition of the shock of the operation to the shock caused by the injury.

The **question of amputation** depends upon the amount of injury done. In some cases there is no object in waiting, because it can be seen at once that the injury is irreparable. For example, where not only the skin but also the bones, the vessels and the nerves are destroyed, there can be no question as to the advisability of amputation. On the other hand, if the blood-vessels and nerves are intact, it may still be possible to save the limb, even although the bones be extensively crushed, and a large area of skin destroyed, provided always that the wound be rendered

completely aseptic. Formerly, if the bones were extensively injured amputation was performed, even although the large vessels and nerves were intact, but sufficient experience has now shown us that, in a very large number of cases, compound fractures can be safely treated under antiseptic precautions, without recourse to amputation. Formerly, also, it was held best to amputate where large portions of the skin were lost, even although both vessels and bones were intact, because violent inflammation and septic absorption, leading to a fatal result, often occurred: if the patient survived, either the wound, owing to the difficulty of contraction, did not heal at all, or if it did, the contraction was so great as to cause great deformity, and render the extremity useless. At the present time, however, these risks can to a certain extent be avoided, and even where extensive portions of skin are lost amputation is not always necessary. In the first place, if the part be disinfected in the manner just described (see p. 64), and if asepsis be obtained, it frequently happens that a considerable amount of tissue which would otherwise have died retains its vitality. In the second place, by the use of skin-grafting when the wound has begun to granulate (see p. 50), the great contraction which would otherwise result is avoided, while at the same time wounds can be got to heal which otherwise would not heal at all. In patients who are very old, or much broken down in health, and to whom a long confinement to bed would be very injurious, more particularly if they are the subjects of renal disease, amputation is however often the safest procedure. Where diabetes is present the cases in which an attempt should be made to save the limb are comparatively few.

(2) **Gangrene due to Pressure.**—Another cause of direct gangrene is continued pressure, and it is very important to remember this when a patient has to be kept in one position for a long time. Under such circumstances, the parts subjected to pressure are very apt to die, and this is more especially the case with soft parts over bony prominences, such as the sacrum, or those subjected to pressure against the edge of a splint. In other words, we have to do here with the condition known as **bed-sore.** The gangrene in these cases is moist.

The **treatment of bed-sore** resolves itself into (*a*) prophylaxis, (*b*) treatment where bed-sore is threatened, and (*c*) where it is actually present.

(*a*) **Prophylaxis.**—The essential points in the prophylactic treatment are in the first place to avoid continuous pressure, or so to vary or diffuse it that it shall not tell too long or too injuriously on one part, and, in the second place, to keep the skin dry. The first indication is carried out by frequently *altering the position* of the patient or the part, or by so arranging matters that the pressure shall not tell on any bony prominence. For instance, the patient may lie on a ring pillow, the opening in the pillow being opposite the part where pressure is to be avoided.

Another and in most cases the best way is to place the patient on a *water-pillow or a water-bed*, so that the pressure does not remain localized

to any one point, but is distributed over a considerable area. In using a water-pillow care must be taken that the proper quantity of water is introduced into it; if too much be present the pillow becomes hard and convex, and does not apply itself equably to the skin, so that as much pressure is exerted upon the part as if there were no water-pillow at all, On the other hand, if there be too little water the patient is not properly supported, and the part comes into contact with the bed. Just sufficient water should be put in to keep the patient floating, and a good method of testing this is to bear one's whole weight on the pillow by pressing the two spread-out hands in the centre; if they just touch the other side of the water-pillow the patient's body will float when laid upon it. The water in the pillow should be tepid when introduced, and it ought to be changed every three or four days, otherwise it is apt to become foul. A large water-pillow must of course be filled upon the bed. The pillow is covered by a drawsheet, and great care should be taken that this is quite smooth and not wrinkled.

A second point in the avoidance of bed-sore is to see that the parts most exposed to pressure are *kept thoroughly dry*. The patient should be turned over twice a day, and the sacrum, or any other region subjected to pressure, should be carefully washed and thoroughly dried, and not only dried, but rubbed gently with a soft towel so as to improve the circulation and the nutrition of the tissues. It is then dusted over with powdered boracic acid.

(*b*) **Where a bed-sore is threatening**, that is to say, where the skin is becoming red, the same measures should be continued, but it is well to relieve the pressure entirely by placing a ring pillow around the part on the surface of the water-bed. In addition to gently rubbing the part with a soft towel, the circulation should be further promoted and the epidermis hardened by the application of some stimulating fluid, such as spirits of wine or whisky. The spirits of wine is allowed to dry on the skin, which is then rubbed, and subsequently dusted with powdered boracic acid. At a later period, when the skin is becoming raw, lint spread with equal parts of balsam of Peru and resin ointment is a very good application; it should be renewed night and morning, after the part has been washed, dried, and rubbed with alcohol.

(*c*) **When a bed-sore has formed**, the slough, and subsequently the sore, must be kept as aseptic as possible. Where the patient is lying on the part it is impossible to carry out one of the chief principles in the treatment of gangrene, namely, to favour the drying of the slough; and that being the case, there is no objection to the use of antiseptic ointments, which is after all one of the most valuable methods of keeping the affected area aseptic. The best is the full-strength boracic or eucalyptus ointment, changed, when the slough has separated, for the quarter-strength boracic. The balsam of Peru, either alone or mixed with white of egg in equal proportions, is also a very good dressing. As soon as possible

the patient should be made to lie on the side, when the sore will usually begin to heal, unless the general condition be extremely weak. At the same time, the general nutrition of the patient should be attended to by the administration of light and easily digested food and stimulants (see p. 64).

(3) Another cause of direct gangrene is **acute inflammation.** Where inflammation occurs in dense tissues, and especially where it ends in suppuration, the stasis and the pressure of the exudation on the blood-vessels may lead to death of the tissues from insufficient blood supply. The best examples of this are acute necrosis following acute suppurative periostitis and osteomyelitis, and the sloughs which occur in the skin in boils and carbuncles. These cases will be dealt with under their respective headings; we need only say here that early free incisions are called for.

(4) Lastly, we have direct gangrene resulting from the action of **heat or cold,** but the treatment of burns and scalds and frostbite will be better dealt with after discussing the treatment of wounds (see Chap. IX.), and we may therefore defer their consideration for the present.

B. Indirect Gangrene.—By indirect gangrene is meant death of tissues where the causal agent does not act directly on the part which dies. There are four groups of indirect gangrene: (1) gangrene due to gradual diminution in the calibre of the blood-vessels; (2) gangrene due to the sudden obstruction of the blood-vessels; (3) gangrene due to imperfect innervation; and (4) gangrene due to general causes such as diabetes, acute fevers, the use of ergot, etc.

(1) **Gangrene due to the gradual diminution in the calibre of the blood-vessels.** Dry or **senile gangrene** is the typical example of this form. The changes leading to senile gangrene affect the arteries, and are in part gradual diminution in the calibre of the blood-vessels, and in part rigidity of their walls so that they do not dilate and contract in conformity with the needs of the tissues. Anything which leads to endarteritis will favour the production of this form; for example, alcoholism is a very potent cause of endarteritis, as are also diabetes and syphilis, and these are among the chief causes of senile gangrene. Another very common cause is atheroma, which is a chronic inflammation of the deeper part of the internal coat of the artery, leading to irregular thickening and rigidity, diminution in its calibre, and even in some cases going on to calcification of the middle coat. In atheroma and endarteritis a further cause of gangrene is the great tendency to the occurrence of thrombosis in the affected vessels, thus leading to complete blocking of their lumen.

It is evident that certain **symptoms**, due to imperfect blood supply, will in most cases precede the occurrence of the gangrene. Thus, one of the chief complaints of the patient, even long before the gangrene occurs, is great coldness and perverted sensation in the feet. He suffers much from tingling, he does not feel the ground properly when he walks, he feels, in fact, as if there were something soft between his feet and

the ground. The further history of the case is that after these symptoms have lasted a varying length of time something occurs which sets up a little inflammation about the foot. Possibly a blister forms as the result of tight boots, or a corn suppurates, or in paring a corn the tissues are injured: some such trivial cause usually leads to inflammation, with the result that the tissues being very weak, gangrene takes place, whereas in healthy tissues the inflammation would have passed off without any trouble. When gangrene has started it goes on very slowly, and it may be weeks or even months before more than the toes die. The appearances are those typical of dry gangrene (see p. 63).

General condition of Patient.—The patient for some time remains in a good state of health, and his chief complaint is the pain which he suffers, and which may be intense. As the result of the severe pain, he becomes sleepless, and after a short time his pulse loses its fulness, and he gets very restless. If the disease be allowed to run its course, the patient will in most cases die of it, being worn out by the pain and want of sleep, or by some septic disease which has its origin at the line of demarcation. In some cases, however, recovery takes place, the line of demarcation forming very slowly, and the dead part being gradually cast off.

Treatment.—In describing the treatment of this form of gangrene, we must consider the prophylactic treatment as well as that called for when the gangrene has actually set in. First, as regards the *prophylaxis.* When an elderly patient comes complaining of the symptoms which have been mentioned as indicating imperfect circulation in the foot, and where on examination of the vessels it is found that they are thickened, or perhaps devoid of pulsation, great pains should be taken to explain the danger, and to point out how slight are the injuries which may precipitate the onset of the gangrene. He should be prohibited from wearing tight boots, and should be specially cautioned to avoid any injury to the foot, however trivial it may appear. Above all he should be warned not to place his feet in hot baths or before a very warm fire, for in the imperfect state of the circulation the heat is apt to bring on gangrene. If his feet are very cold, he may place them in a bath of from 80° to 85° F., tested by a thermometer, and he may then have them gently rubbed with a soft towel. He should wear warm stockings, and warm, light, fur-lined shoes or slippers. In bed he should wear thick bed-socks, and the bed may be warmed with hot bottles, which however should either be taken away before he gets into bed, or removed to such a distance that his feet cannot reach them, and in all cases the bottles should be wrapped up in thick flannel. At the same time the diet must be nourishing, and plenty of fresh air and light exercise should be insisted upon.

Directly gangrene has actually occurred, or as soon as it is evident that it is inevitable, the first essential in the treatment is to disinfect the part thoroughly in the manner already described (see p. 64), and to favour evaporation of fluid from the tissues. Above all things, ointments, carbolic

oil, and other greasy dressings should be entirely avoided, and only those employed which permit drying of the part. The cyanide gauze next the skin, with some sterilized or salicylic wool outside, probably forms the best dressing. The patient should remain in a recumbent position, with the foot kept warm and slightly elevated. The strength must be supported by generous diet and fresh air, obtained if possible by wheeling the patient out in a suitable reclining chair every day. The heart's action must be assisted as far as possible, and for this purpose the use of Tinct. Nucis Vomicæ in 5-minim doses, combined with 5 minims of the Tinct. Digitalis, three times a day, is of great use. Steps should also be taken to relieve the pain, more especially by the free administration of opium. Opium has a very beneficial effect in many cases of senile gangrene, even where there is no diabetes. It probably acts mainly by relieving the pain, and thus enabling the patient to get sound rest and sleep ; but some authorities seem to consider that opium has a specific action in gangrene. It should be given four times a day, beginning with 10 to 12 minims of laudanum, and gradually increasing the dose. At the same time the bowels must be kept freely open, preferably by the use of mineral waters, such as a wine-glassful of Hunyadi Janos, or half a tumblerful of Friedrichshall in warm water every morning on rising, or with seidlitz powders and enemata. Stimulants will probably be required, certainly at a later period, and whisky and brandy, in amounts from 3 to 6 ounces daily, are the best.

At an early period the *question of amputation* must be carefully considered. The old rule was that amputation should never be performed in senile gangrene, but that the part should be allowed to drop off, the utmost surgical interference allowed being to snip through dead tendons or bones, and on no account to interfere with the living tissues. The reason for this was that before the antiseptic era acute inflammation almost always followed amputation, and when inflammation occurs in these weak tissues it is very likely indeed to lead to sloughing of the flaps and more rapid progress of the gangrene, which then becomes of the moist variety. At the present time however we can avoid this inflammatory disturbance, and therefore the rules as regards amputation in senile gangrene are completely altered. It is now not so much a question of recurrence of gangrene in the stump, as whether the patient has sufficient recuperative power to recover from the operation. In cases where the answer to this question is doubtful, it must be remembered that the patient if left alone will almost certainly die from the senile gangrene, and therefore that amputation offers practically the only chance. By operating early, and by amputating well above the dead part, the patient's strength is preserved, he is not worn out by pain and loss of sleep, and he is in a much better condition to survive the operation than if it were delayed. The only difficulty is that it is not always possible to gauge how far the process will extend ; as a rule this can be determined by ascertaining the point at which pulsation in the main vessels ceases. In some rare cases where the artery can be felt

beating strongly at the ankle joint, amputation may be performed there, preferably by means of an internal flap. In most cases the pulsation at the ankle is very slight, if present at all, and if pulsation cannot be felt there the best place for amputation is the knee joint. The thrombus which forms in the diseased vessels when the amputation is done through the ankle is very apt to extend upwards as far as the knee and lead to gangrene of the flaps. Generally, therefore, amputation through the knee joint is more suitable.

(2) The second form of indirect gangrene is that due to some **sudden obstruction of the blood-vessels.** This may be the result, firstly, of pressure outside these structures, for example, after ligature, the application of tight bandages, pressure from the fractured ends of bones, etc.; secondly, of rupture of their walls, as, for example, in dislocations or in attempted reduction of dislocations; and, thirdly, of blocking of their lumen, more especially embolism with subsequent thrombosis.

In the first two cases the vein may be blocked as well as the artery, and while this makes no essential difference in regard to treatment, the symptoms vary somewhat. Where the obstruction is primarily arterial, the first thing that is noticed is that the limb below becomes pallid from absence of blood; it then assumes a dark livid colour, and the various changes already described as characteristic of moist gangrene follow. In embolism there is, in addition to the sudden whiteness of the limb, violent pain at the point where the embolus has been arrested, and this is a very valuable sign as showing where the block has occurred. When, however, the case afterwards comes to amputation it must not be assumed that the seat of pain is the upper limit of the obstruction, because, subsequently to the embolism, thrombosis takes place and may extend upwards for a considerable distance. If there be venous as well as arterial obstruction at the commencement, the part below remains dark and becomes œdematous very quickly.

In these cases the **treatment** depends on the extent of the gangrene, and the great question for consideration is that of amputation. Before deciding this point, sufficient time should be allowed to elapse to enable the surgeon to see how much of the collateral circulation will be established, because although at first the part may appear white and dead, a very considerable portion, or indeed the whole, may recover as the result of the enlargement of the anastomotic circulation. While waiting, however, precautions must be taken not to allow putrefaction to occur, and also to permit drying. The skin, the toes, and the nails should be at once disinfected in the manner already described (see p. 64), and the part wrapped up in a warm antiseptic dressing, permitting evaporation, which should be allowed to remain in position for 24 or 48 hours. If gangrene occur the part very soon loses its white colour and becomes dusky and remains cold. The finger firmly pressed into the skin makes no difference to the colour; whereas if the circulation be maintained, the part pressed upon becomes

white, and slowly or quickly regains its original appearance when the pressure is discontinued. When recovery takes place, it does so within the first 24 hours, and when it is certain how much is going to die, amputation should be practised without further delay. There is no necessity to wait for the formation of a line of demarcation.

The point at which amputation should be done depends on the anatomy of the arteries and on the extent of recovery. It should, however, be borne in mind that the gangrene is generally less extensive in the skin than in the deeper parts, and therefore, if the flaps are cut close to the gangrenous part, the incision will probably go into dead tissues as it is deepened. Hence an interval of at least two or three inches should intervene between the line of gangrene and the amputation incision. In many cases, however, amputation is done higher up than this on account of the better stump obtained, or on account of the better anastomotic circulation. Where there is blocking of the veins as well as of the arteries, the chances of recovery are less, but the rules of treatment are the same.

(3) The third form of indirect gangrene is that dependent on **imperfect innervation** of the part. Where a limb is paralysed, the nutrition is almost always deficient, and such limbs are especially liable to the formation of bed-sores and gangrene from pressure. In hemiplegia also, where the patient is lying absolutely still, he is extremely liable to suffer from bed-sores which are worse on the paralysed side than on the sound one. Again, if extension be applied both to a paralysed limb and to a sound one, there is much greater liability for sloughs to form under the extension plaster on the paralysed than upon the sound side.

The gangrene that occurs in these cases generally comes on very quickly. It is moist, and is often spoken of as an **acute bed-sore**, and it is very important to remember that under such circumstances the greatest possible care should be taken to avoid, as far as possible, even the slightest pressure. The part must be examined frequently to see that its condition is good, and the limb should be kept warm and slightly elevated; should sloughing occur, the case must be treated like one of bed-sore (see p. 67).

There is another form of gangrene in connection with nervous derangements, which chiefly comes under the notice of the physician. This is what is termed symmetrical gangrene or "**Raynaud's Disease.**" This form differs from senile gangrene, which it in some respects resembles, in that it is always bilateral, while senile gangrene is often one-sided; that it more often affects the fingers than the toes; that it is much more limited both in extent (generally not reaching beyond the phalanges) and in depth (seldom going deeper than the skin); and that in "Raynaud's disease" the blood-vessels are normal, whereas in senile gangrene they are thickened and hard. Raynaud's disease occurs especially in hysterical women between eighteen and thirty years of age, and is most probably connected with uterine and menstrual troubles. The attacks are often brought on by cold, and are most commonly met with during the winter

months. It is supposed to be due to spasm of the arterioles brought about reflexly by the uterine disorder.

In this affection certain phenomena precede the gangrene. The extremity affected may become quite white, and this is evidently due to contraction of the blood-vessels; following this, or occurring without any preliminary pallor, the parts may become of a deep purple colour, as if they had been dipped in ink. This is evidently due to a local venous condition of the blood, from great slowing of the circulation. It may last for a day or two, and may or may not lead to gangrene. The gangrene is of the dry form. The darkness of the extremities just noted continues for some days, the pain and other symptoms increase, and small bullæ may possibly form. Indeed, in the case of the hand, it often looks as if the patient were going to lose all the fingers. Ultimately the circulation improves very much, and as a rule the final result is that only a small piece of tissue dries up, and ultimately separates. The whole process is very slow and takes from the commencement of the gangrene to the separation of the slough from twenty days to ten months. The disease is very apt to recur.

Treatment.—In the treatment of the **local** condition, the first place must be given to the use of stimulation by the electrical current. For this purpose the *constant current* may be used, and, as recommended by Dr. Barlow, the extremity of the affected limb should be immersed in a large basin containing salt and water. One pole of the constant current battery is placed on the upper part of the limb, whilst the other is immersed in the fluid in the basin, which is thus converted into an electrode. As many cells may be employed as the patient can comfortably bear, and the current is made and broken at frequent intervals, 20 to 30 per minute, so as to get repeated moderate contractions of the muscles of the limb. Where several of the extremities are affected, and where it is possible to obtain it, the complete electric bath is best.[1] The bath itself should be of porcelain, earthenware, or wood, about 5 ft. 6 in. long, and the patient should be entirely immersed up to the neck when lying in it. The water should be just under 100° F. The electrodes are large flat copper plates fixed to the poles of an induction coil, and should be about one foot square; they are placed at the head and foot of the bath. The shoulders should not touch the electrode, the feet may be allowed to do so. The current used to begin with should not exceed 100 milliampères: after a few baths it may gradually be raised to 150 or even 200, if it is not painful. The current should not be turned on until the patient has been in the bath some little time, and then only very gradually. The bath should last from 10 to 15 minutes, and should be repeated daily for the first week; then three times a day until about a dozen to fifteen baths have been taken. This is generally sufficient to produce considerable

[1] For further information concerning the use of the electric bath the reader may be referred to Dr. Lewis Jones' excellent work on *Medical Electricity*, 2nd edition (H. K. Lewis, London), to which we are indebted for several of the above points.

improvement. Another mode of carrying out the same treatment is to carefully sponge or rub the limb over with two sponge electrodes held a short distance apart, and this is very useful in reducing the pain that is usually present. This method of electrization may also be employed even where gangrene has actually occurred, being then of course used for the relief of pain in the surrounding parts.

The application of the current generally produces a somewhat profuse perspiration, and is usually unaccompanied by pain, and an important change, showing that the current is doing good, is that the hands frequently become moist, where previous to its application they were harsh and dry. This, by Raynaud himself, is considered one of the most favourable elements of prognosis. He also points out that when this treatment has been followed for some days, and improvement has distinctly commenced, certain unpleasant effects may begin to manifest themselves; for instance, headache, which is intensified by the passage of the current, a painful sensation of constriction in the throat and general excitement. He states that, although these symptoms are not serious, yet, should they occur, it is proper to diminish the number of elements employed.

Another very useful form of treatment, and one that may often be advantageously combined with the use of electricity, is careful *friction* or shampooing. In some cases this, however carefully it is carried out, cannot be borne by the patient; but it will generally be found that, after electricity has been employed for some little time in the manner just recommended, the parts are sufficiently free from tenderness to bear careful shampooing. This should be performed at first by the hand, encased in soft flannel or other suitable gloves. After a time friction by the naked hand, anointed with some simple lubricant, may be substituted. This shampooing may also be used with advantage for those cases where, after repeated attacks of gangrene, the limb has become contracted and anchylosis has occurred. Under these circumstances it is of course used with a different object, namely, to promote the nutrition of the muscles and to facilitate the movement of the various joints. The friction may be carried out immediately after the application of the current, and may be repeated more than once during the day if the patient experience sensible relief from its use.

In cases where, during the height of the spasm, there is intense and agonizing pain, considerable relief seems to be afforded by the application of slight *cold*, and this appears to be more effectual, at any rate in abating the pain, than the use of hot fomentations. For this purpose the extremities may be covered loosely with a piece of lint, which is dipped in eau de Cologne, or some similar evaporating spirit, diluted with water. In cases of extremely grave local asphyxia, where gangrene was obviously impending, Raynaud has made use of the application of leeches with apparently satisfactory results. This method, however, should not be employed except where the condition is grave, as with it septic complications are not at all

unlikely to occur. Wherever it appears imperative to relieve the local congestion, we should prefer the use of scarifications (after the skin, etc., had been rigorously purified) followed by the application of warm fomentations to encourage bleeding.

General Treatment.—With the local applications must be combined the administration of internal remedies. Of course, if there be a marked hysterical condition, the patient may be treated by massage and careful feeding, combined with isolation, as recommended by Weir Mitchell. Apart from this, some drugs seem to be of benefit, although there is apparently none that may be looked upon as having any specific effect upon the affection. Chief among these is *opium*, which is useful in some cases. Possibly it may to a certain extent allay the spasm, or at any rate calm the agonizing pain that is often present, and in these cases it may be used with considerable advantage. The administration of *quinine* in doses of three or four grains three times a day is also in some cases likely to be of use, both constitutionally and to the local condition. If there be pronounced anæmia, *iron* and *arsenic* may be administered, the former as Blaud's preparation in capsules of five to ten grains three times a day, the latter in the form of Fowler's solution, beginning with a dose of three drops upon a piece of sugar taken three times a day, and gradually increased until twelve or fifteen minims are taken at a time. *Nitrite of amyl* has been recommended from a theoretical consideration of its action, but apparently without any marked benefit. Any uterine or ovarian trouble should be looked for, and if present should receive appropriate treatment. In addition to the use of drugs, the patient should be encouraged to take plenty of light food and to have sufficient exercise in the fresh air. The affected limb should of course be wrapped up warmly in flannel or lambswool, and the greatest care must be taken to avoid exposing the extremities to sudden and extreme alterations of temperature. When sloughing has actually taken place, the treatment already described for dry gangrene must be carried out, antiseptic dressings being used, and the part allowed to dry up. In no case is amputation necessary.

(4) The fourth form of indirect gangrene, due to **general causes,** is in some ways the most important of all. Three varieties may be mentioned, namely, (*a*) gangrene in connection with diabetes, (*b*) gangrene after acute fevers, and (*c*) gangrene following the use of ergot.

(*a*) **Diabetic Gangrene.**—There are two ways in which diabetes may be related to gangrene. First, there is the death of the part directly dependent upon the presence of diabetes, or the true "diabetic gangrene"; second, there is gangrene from some other cause taking place in a patient who is diabetic. In any case, the presence of diabetes affects the progress of the gangrene in a very marked degree; it spreads with greater rapidity, there is more inflammation about the gangrenous part, and the gangrene, if dry at first, tends to become moist. The patient generally dies either of some septic complication, of diabetic coma, or of exhaustion.

Diabetes leads to gangrene, in the first place, because it gives rise to endarteritis, and consequent diminution in the calibre of the vessels; and in the second place, because the tissues of the diabetic are weaker and less able to resist injury than healthy ones; they are especially sensitive to the pyogenic organisms which appear to grow in them with special rapidity and virulence. Some authorities also hold that the innervation of the tissues is interfered with as the result of central nervous disturbance, and that they are thus predisposed to gangrene.

Treatment.—Bearing in mind the great tendency to gangrene, diabetics must be specially warned to avoid any injury, however trivial, lest acute inflammation, which will probably become gangrenous, should result; more especially they should avoid slight injuries to the feet, the wearing of tight boots, etc. Strict asepsis should be employed in the case of any wound from which they may suffer, and when gangrene has set in the usual treatment should be adopted, namely, the disinfection of the limb and the application of an antiseptic dressing.

(1) **General.**—The general condition should be specially attended to and the patient placed on anti-diabetic diet, that is to say, he should avoid substances that tend to the production of sugar, such as sugar itself, all starchy foods, potatoes, etc. The stringency of the diet must depend on the amount of sugar in the urine and the condition of the patient; if he be very weak it is inadvisable to put him suddenly on too strict a diet. The following dietary, for which we are indebted to Dr. Burney Yeo,[1] will give full details as to the diet of a diabetic patient.

SEEGEN'S DIETARY.

Sanctioned.

In any quantity—Flesh of all kinds; preserved (smoked) meats, ham, tongue, bacon; fish of all kinds; oysters and shell-fish; crabs, lobsters; animal jellies; aspic; eggs, caviare, cream, butter, cheese; spinach, cooked salads, endive, cucumber, green asparagus, watercress, sorrel, artichokes, mushrooms; nuts.

In small quantity—Cauliflower, carrots, turnip, white cabbage, green beans; berries, such as strawberries, raspberries, currants; also oranges and almonds.

BEVERAGES.

In any quantity—Water, soda-water; tea, coffee; Bordeaux, Rhine, and Moselle wines; Austrian and Hungarian table wines. In short, all wines that are not sweet, and that contain only a moderate amount of alcohol.

In very small quantities—Milk, unsweetened; almond emulsion; brandy, bitter beer; lemonade, unsweetened.

[1] *A Manual of Medical Treatment or Clinical Therapeutics*, Vol. II., p. 554. Cassell & Co., London, 1893.

Forbidden.

Farinaceous foods of all kinds (bread only in very small quantity according to the discretion of the physician); sugar; potatoes, rice, tapioca, arrowroot, sago, groats; peas, beans; sweet fruits, as grapes, cherries, peaches, apricots, plums, and all kinds of dried fruits.

BEVERAGES.

Champagne and sweet wines and beers, must, fruit wines and fruit juices and syrups; sweet lemonade; liqueurs; ices and sorbets; cocoa and chocolate.

Opium, or still better, *codeine*, which is said to diminish the irritability of the afferent nerves of the liver, should also be employed in large quantities. The codeine is given at first in doses of a quarter of a grain three times a day, and this may be gradually increased up to five grains. Stimulants may also be necessary if the pulse is becoming weak, and the patient exhausted; the best are dry wines, such as dry sherry, whisky in small quantities, etc., whilst sweet wines, champagne, and the like should be strictly avoided.

(2) **Local.**—*Question of amputation.* From an early period one must consider the question of amputation. Formerly the rule was not to amputate in diabetic gangrene, partly on account of the great tendency to inflammation and suppuration in the stump, leading to extension of the gangrene, and partly owing to the risk of death from diabetic coma. Here, again, the rules have been completely altered by the employment of antiseptic measures, and from recent work it seems quite evident that the best treatment in most cases is early amputation. If left alone the great majority of patients die. By strict asepsis inflammation in the stump is avoided, septic troubles are prevented, and further gangrene does not occur if the amputation be performed sufficiently high up. The principal risk is from diabetic coma, and although this may be to some extent increased by the use of an anæsthetic, more especially of chloroform, the patient is not really more liable to an attack of diabetic coma after amputation than he is during the course of the gangrene; and, as he is very likely to die of coma if not operated upon, this danger does not seem to present a barrier to operation.

(*b*) **Gangrene after acute Fevers.**—Gangrene from this cause is sometimes a sequela of typhus or typhoid fevers, and attacks the extremities and the parts farthest from the heart, especially the toes, the nose, the ears, and sometimes the fingers. This form of gangrene is generally due to endarteritis and thrombosis; in some cases, however, it follows embolism. It usually begins during the period of convalescence and is dry; it is unilateral in the case of the extremities.

Treatment.—The treatment is to disinfect the part, apply an antiseptic dressing (see p. 64), and, in the case of the extremities, to wait for a line

of demarcation before amputating, partly because the exact amount of tissue that will die cannot be known, and partly because the patient's condition is generally so bad at the onset of the gangrene that amputation would be very apt to cause death. In addition, it is important to support the patient's strength (see p. 64) and treat any symptoms which may arise.

(*c*) **Gangrene from Ergot.**—This form of gangrene may occur in epidemics, when the rye in certain districts has become infected with the ergot fungus (*claviceps purpurea*) and where families eat large quantities of this infected rye in the form of rye-bread. The early effect of ergot is to produce tetanic contraction of the smaller blood-vessels, and if this be kept up for a long time, it may lead to gangrene, more especially of the extremities.

Certain symptoms, such as diarrhœa, buzzing in the ears, cramps, coldness of the extremities, etc., precede the occurrence of gangrene. The affection most usually attacks men between thirty and forty years of age. The form of gangrene is usually dry, but in certain cases it may be moist, and it may vary in extent from the loss of a nail to the loss of a limb.

The **treatment** consists, in the first instance, in removing the cause. If there are the premonitory symptoms of ergot poisoning, or the epidemic occurrence of gangrene in young patients who are otherwise healthy, the food must be examined, and if the claviceps be present, untainted bread must be substituted. Great attention should be paid to the nutrition of the patient, and the use of strong coffee is highly recommended as an antidote.

As regards the local treatment when gangrene has set in, the patient must be kept in bed, and the part disinfected and kept aseptic; but before deciding on amputation a line of demarcation should be waited for, because it is impossible to say how much of the tissue will die. As a rule the line of demarcation when it has once formed is permanent, and therefore, as soon as it is well-marked, the best method of fashioning the flaps can be decided upon and amputation performed without any further delay.

C. Infective Gangrene.—The third great group of gangrene is that due to specific infective organisms. In former days, as the result of sepsis, a variety of gangrenous processes attacked wounds, but they are very seldom seen now. It will be sufficient if we speak here of three forms of specific gangrene, namely: (1) acute traumatic gangrene; (2) phagedena, and (3) cancrum oris or noma.

(1) **Acute Traumatic Gangrene.**—This is a form that attacks wounds and is due to the growth of bacteria in the tissues; it especially attacks wounds which have been soiled with earth. It is probably due to a bacillus resembling that which produces symptomatic anthrax in cattle and malignant œdema in some of the lower animals. The disease begins soon after the accident, usually about the second or third day. Its course is as a rule very rapid, averaging about three days before the death of the patient; the part becomes greatly swollen and œdematous and crepitates

from the presence of gas which is developed in the tissues in enormous quantities.

Treatment.—The first point in the treatment is **prophylaxis.** Where wounds are soiled with earth or dirt especial care should be taken to disinfect them, and the best plan is to place the patient under an anæsthetic, to scrub out the earth with a nail brush and the strong mixture, and then to apply undiluted carbolic acid to the whole surface of the wound. It must be remembered that acute traumatic gangrene is not the only disease which results from soiling of wounds with earth, malignant œdema and above all tetanus being very often produced in a similar manner. Hence thorough disinfection of such wounds is imperative.

Local Treatment.—In acute traumatic gangrene of the extremities, when the disease has once been established, *amputation* offers the only chance of saving the patient. Almost all the patients attacked by this affection die, and unfortunately even with amputation only about 5 per cent. recover, because, unless at a very early stage, it is extremely difficult and often impossible to get above the disease. In amputating, the very greatest care must be taken to disinfect the skin and more especially to avoid soiling the amputation wound with the discharge from the gangrenous part. Hence, in addition to the ordinary disinfection of the skin at the seat of amputation, the gangrenous extremity should be wrapped up in antiseptic gauze which has been wrung out of the strong mixture, and this is firmly fastened round the limb, well above the upper limit of the gangrene, so that none of the contents of the bullæ, etc., can run out. This is done by an assistant who is not afterwards allowed to take any part in the operation. In operating on these cases the use of strychnine and the other measures employed in the prevention of shock (see Chap. VI.), should be especially attended to.

The **general treatment** consists in the free administration of stimulants and a generous diet.

(2) **Phagedena.**—The second form of specific gangrene is phagedena, a disease practically never seen nowadays, but formerly very common, especially in times of war. It is undoubtedly a parasitic affection, but the exact nature of the organism is unknown. It consists essentially in the production on the wound of a pseudo-membranous material, beneath which the tissues ulcerate or become gangrenous, and two forms, namely, an ulcerative and a gangrenous one, are usually described. In the ulcerative form a pulpy membrane appears on the surface of the wound; beneath this, cup-like losses of substance occur, and subsequently rapid ulceration takes place along the planes of the tissues. In the other form, the wound becomes covered with a thicker membrane, which is dark coloured, very pulpy, extending rapidly, leading to sloughing of the skin and muscles, and not uncommonly attacking the vessels and giving rise to severe hæmorrhage. The disease spreads with great rapidity, and the patient dies in from twenty-four to forty-eight hours.

Treatment.—The **prophylactic** treatment consists of strict antiseptic precautions in cases of all wounds, isolation of the affected individual, and great care not to infect other persons with the instruments, or by the attendants.

In the **local treatment** the chief reliance is placed on destruction of the pulpy material, either by the application of the actual cautery, or by the use of nitric acid (see p. 59) or perchloride of iron, the pure liquor ferri perchloridi being employed. Of these the actual cautery seems to be the most efficacious. The parts are very thoroughly destroyed with the cautery at white heat, wherever there is the slightest suspicion of the presence of the membranous material. After the surface has been destroyed with the cautery, the wound should be packed with boracic lint dipped in 1-5 carbolic oil. If perchloride of iron be used the wound should be first thoroughly dried, and lint soaked in the perchloride packed into it and left for four-and-twenty hours, after which it may be dressed with the boracic lint and carbolic oil. The perchloride of iron has not a very powerful effect in this disease and should only be employed where it is slight in extent and is not spreading rapidly. If the part affected be an extremity, amputation should be performed, provided it be possible to get well above the disease. Naturally, great care must be taken not to infect the stump at the same time.

In any case, the **general condition** of the patient should be attended to, stimulants, strychnine, etc., being freely administered, and every effort made to maintain the patient's strength.

(3) **Cancrum Oris.**—The third form of specific gangrene to which we shall refer is cancrum oris, a disease affecting children, and beginning in the mouth or the vulva (when it is termed "noma."). This disease generally attacks weakly children of from two to five years of age, who are convalescing from some other affection, such as measles or scarlatina. In the mouth, it usually begins in the gums; the patient complains of pain, the breath becomes fœtid, and there is increased flow of saliva. Ulceration then occurs about the gums, a black spot appears inside the cheek, and by and by this extends through the cheek, a slough forms, and large portions of the jaw and cheek may be destroyed. The patient's general condition is very serious, the temperature is high, and death usually occurs in from three to four days. The disease is due to long delicate bacilli which are found in large numbers in the slough, and more especially in the living tissues just beyond it.

The **treatment** aims at destroying all the affected parts, and the portions of the living tissues around in which the bacilli are present. All the parts which are gangrenous must be clipped away; not only the soft parts, but the portion of the jaw affected must be removed, and this should be done till a surface which bleeds everywhere is exposed. Having in this way got rid of all the gangrenous tissues, pressure is applied and the bleeding arrested, and then strong nitric acid is painted over or rubbed into

the raw surface. This is best done by means of a stout glass rod or a glass brush. The acid is allowed to act for about ten minutes, fresh applications being repeatedly made during that time. When the surgeon is thoroughly satisfied that every portion of the disease is destroyed, the action of the acid is arrested by the application of a saturated solution of carbonate of soda, which is poured on the part until the acid is completely neutralized, as is shown when bubbles of carbonic acid gas cease to form. Anything short of this treatment will fail in arresting the disease. To leave the sloughs on the surface and to apply antiseptic washes or strong antiseptics to them is absolutely useless, for the regions in which the organisms are growing are the living tissues just beyond the actually dead parts, and these cannot be reached unless the slough be first removed. The part should then be powdered with iodoform, and full-strength boracic ointment spread on butter-cloth applied with boracic lint outside it. The mouth or vagina should be washed out with sanitas and water (about 1 part in 12) several times a day. The wound will begin to granulate in five or six days, and then the weaker boracic ointment may be substituted. Stimulants are necessary, and also nourishing diet, and probably, at first, strychnine will be required. Great deformities are left after this disease, especially in the cheek, but these will be dealt with when we come to consider the plastic surgery of the face and jaw.

CHAPTER V.

ANÆSTHETICS.

By Dr. J. Fredk. W. Silk.

The two chief objects in placing a patient under an anæsthetic, are the abolition of pain and the diminution of shock; of but slightly less importance, from the surgeon's point of view, are quietness and muscular relaxation. To attain these ends, a general anæsthetic, by which is meant the inhalation of some particular gas or vapour, is almost essential. Shock, quietness, and muscular relaxation are, no doubt, partly dependent upon the amount of pain inflicted, and in certain selected cases, therefore, local anæsthesia by means of hypodermic injections of cocaine, or the infiltration method of Schleich, or freezing, may be sufficiently satisfactory. As far as our present knowledge goes, however, no method is at once so certain, so universally applicable, and so complete as that of general anæsthesia by inhalation.

PART I.

GENERAL ANÆSTHESIA.

Preliminary Observations.

Preparation of the Patient.—With the possible exception of nitrous oxide (see p. 87), experience leads us to believe that an anæsthetic is always taken better if the patient has been subjected, for a few days, to what may be termed **hospital regime.** This does not of necessity mean absolute confinement to bed, but it implies rest of body and mind, careful regulation of the ordinary bodily functions, light and easily digested diet, abstention from alcohol, etc. Obviously, it is not always possible, nor even advisable, to submit every patient to such restraint; for instance, young children and highly neurotic adults are often best kept in ignorance of an impending operation, but such patients frequently give trouble under an anæsthetic, and so confirm the value of the general rule.

It has been suggested that a course of some **drug,** such as strychnine, quinine, iron, etc., is a sure safeguard against some of the difficulties and

dangers which may arise during the administration of an anæsthetic. The tonic properties of such substances are, no doubt, of value, but it has not yet been proved that any of them possess a specific action in the matter.

A **purge**, in the shape of castor oil, compound liquorice powder, calomel, colocynth, or compound rhubarb pill, should always be given the night before the operation, and, if necessary, an enema in the morning; this may consist either of plain water or soap and water. The latter is made by rubbing up Castile soap in warm water until a thick lather is formed, and about a pint is injected.

Diet.—Of greater consequence is the axiom which insists upon an empty stomach; but starvation may be carried too far, especially in the feeble. Each case should be treated upon its merits, according to the digestive capacities and general health of the individual, and bearing in mind that the mere dread of the operation will often retard the digestion for hours. The **best time for operating** is the early morning, in which case no food need be given after supper on the previous evening. If the operation be fixed for the afternoon (at or after 1 P.M.), a light breakfast may be taken not later than 8 A.M., and a cup of hot broth or beef tea, or even hot water alone, may be given not less than three clear hours before the actual time of operation; this is useful in counteracting the feeling of exhaustion and faintness, of which many persons complain if kept fasting too long. Milk and other slowly digestible substances should always be avoided.

In cases of special gravity, either from the condition of the patient or the probable severity of the operation, it will be found useful to give, when possible, a **nutrient enema** (yolk of one egg, one ounce each of beef-tea, milk, and brandy, peptonised,[1] if the patient be particularly exhausted), half an hour before he is placed upon the table, care being taken to wash out the rectum with warm water before the enema is injected.

Alcohol.—Physiologically or clinically considered, the use of brandy by the mouth is irrational, as it encourages the tendency to retching and vomiting, and increases the poisonous effects of the anæsthetics. It may become necessary, however, in cases of impending syncope, and in some few instances its administration may have a good moral effect, but, as a general rule, it is not desirable.

Hypodermic medication immediately before the inhalation, has been advocated, the drugs used being morphine, atropine, strychnine, digitaline, etc. The routine use of **morphine**, even in combination with **atropine**, is deprecated by most anæsthetists; its advantages are more theoretical than

[1] To peptonise, add 15 gr. Bicarbonate of Soda and a dessertspoonful of Benger's Liquor Pancreaticus or 5 gr. of Fairchild's Zymine. Place the jar containing the mixture in a basin of water as hot as the hand can bear (about 150° F.). Allow it to remain for half an hour, then heat it quickly to boiling point for one minute. Cool before injecting.

practical, and its tendency to mask the symptoms of over-narcosis has more than once led to fatal results. Something may be said in its favour, when used in such special operations as those involving the cerebral hemispheres, where it may help to keep the parts anæmic, but even then only a small dose should be employed ($\frac{1}{8}$–$\frac{1}{4}$ gr.). There seems to be some reason for believing, that **strychnine** is of considerable value in obviating or diminishing what may be termed "operation shock,"[1] and it is also claimed by some, that the tendency to sickness is lessened by its use. In the feeble, therefore, and in severe operations, $\frac{1}{30}$ grain may be injected, either immediately before or immediately after anæsthesia is induced, and the dose may be repeated once or twice during the course of the operation; this does no harm, and may do a great deal of good.

Before the inhalation is commenced, every care must be taken to remove anything that may interfere in the slightest degree with the most **absolute respiratory freedom**; even in normal sleep the least pressure on the chest may cause an immense amount of discomfort. Plugs of tobacco, artificial teeth, obturators, etc., should be removed, lest they fall into the larynx or pharynx; collars, stays, belts, waistbands, braces, bandages, etc., etc., must be completely relaxed.

In some instances, **auscultation** of the chest and heart increases the trepidation of the patient, and, in by far the majority of cases, the information obtained is valueless or misleading; on account of nervousness the rate and rhythm of both cardiac and breath sounds are much interfered with, and the accurate detection of slight lesions becomes almost impossible. Although auscultation is not to be recommended as a routine practice, the anæsthetist is bound, nevertheless, to acquaint himself, through the medical attendant, or through the patient and his friends, with all points in the medical history of the case which may have any bearing upon the question of the anæsthetic, especially in connection with the respiratory and circulatory systems; in cases of doubt, or if the slightest desire for it be manifested by the patient or his friends, a careful examination should, of course, be undertaken. It will probably help to calm the patient if the pulse be felt, although but little real information is gained beyond detecting any marked thickening or atheroma of the arterial walls.

The **position of the patient** on commencing the inhalation, must vary slightly under different circumstances. Fussy attempts to "arrange" the patient are to be deprecated, and, generally speaking, the best rule to adopt is, to allow the patient to assume the recumbent posture most convenient and comfortable to himself. In most instances this will be supine, when, especially if there be any tendency to emphysema, the head and shoulders should be well supported with pillows. With the patient sitting up (nitrous oxide or ether), care must be taken that the head is placed in

[1] Prof. Wood of Philadelphia, *Transactions of the International Medical Congress*, Berlin, 1890, vol. i., p. 133.

such a position that the tongue does not fall back over the glottis. In some few cases, the patient naturally assumes the lateral position, and in this the anæsthetist should acquiesce. The great object in view is, to make the necessarily disagreeable, preliminary stages, as short, and as little unpleasant as possible.

The choice of the Anæsthetic.—To a considerable extent the comfort of both patient and operator, and to some extent the actual safety of the patient, depends, not only upon the skill of the administrator, but also upon the particular anæsthetic used. As far as the choice of the anæsthetic is concerned, the patient, the operator, and the anæsthetist himself are all factors which have to be considered before making the final selection, so that it is almost impossible to do more than lay down very general rules; each individual case must be decided upon its own merits.

In the first place, it is obvious, that rules that are intended for those with whom it is not a matter of absolutely every-day experience to administer an anæsthetic, cannot have the same weight when applied to the specialist. An example of this is seen in the use of ether. When plenty of practice in the administration of this drug is obtainable, it may be given in the majority of cases; but, on the other hand, when only used very occasionally, the results are apt at first to be disappointing, unless the cases are carefully selected. In the second place, some surgeons object to the use of particular anæsthetics in certain operations. For example, some surgeons consider that chloroform alone should be given in abdominal cases, while most anæsthetists are of opinion that ether does equally well. In cases such as these, it is probably to the best interests of the patient to adopt the views of the surgeon; the latter ought not to be allowed to feel, or even to imagine, that his work would have been better done, had a different anæsthetic been used. In the third place, it may be laid down as an axiom, that it is unwise to employ a stronger anæsthetic than is absolutely necessary. The relative strength of the various substances may be assumed to be as follows, commencing with the most feeble, viz.: nitrous oxide, ether, diluted chloroform (the A.C.E. and other mixtures), and pure chloroform.

Factors determining choice of Anæsthetic.—In choosing an anæsthetic, the most important of the determining factors are those which concern the patient himself, and the nature, etc., of the operation to be performed; these must, therefore, be considered a little more in detail. A distinction, too, must be drawn between the anæsthetic with which it is advisable to induce or commence the anæsthesia, and that with which it is possible to maintain or continue it.

(1) **Duration of the Operation.**—Nitrous oxide is available in short operations of under two or three minutes. These include such operations of minor surgery as opening superficial abscesses, dilating and slitting up sinuses, some tenotomies, removing small aural polypi, passive movement of stiff joints, and, of course, the extraction of teeth.

(2) **Position of the Patient.**—Neither chloroform, nor any mixture containing that drug, should be used with the patient sitting up in a chair; such a proceeding is *absolutely unjustifiable.* Operations upon the cerebral hemispheres, and upon the mouth and tongue, do not really constitute exceptions to this general rule, for although the body is then often raised, the feet and legs remain horizontal; even in these cases too, the more nearly horizontal the patient can be brought the better.

(3) **Age of the Patient.**—Some anæsthetists see no objection to the use of ether at any age, while others prefer to induce narcosis with chloroform in the very young, and continue with ether afterwards. Until sufficient facility in the use of ether has been acquired, and unless one has constant practice with the drug, it is better to adopt some such age-limits as the following:

Under 3 years of age, . . .	Chloroform all through.
From 3 to 12, ...	A.C.E. all through.
From 12 to 60, ...	Ether all through.
Over 60, ...	Induce with A.C.E., increasing the proportion of ether in long operations.

It is usually asserted, somewhat dogmatically, that children always take chloroform well. It must not be forgotten, however, that many accidents have occurred, and that in the opinion of some people the death-rate with children is as high, or even higher, than with adults. This *apparent immunity of children* from fatal accidents under chloroform, is due to many causes, among which may be mentioned the undoubted fact that, owing to their greater vitality, children respond more readily than adults to any efforts that are made in the direction of resuscitation.

(4) **Condition of the Patient.**—Here, again, some anæsthetists admit of but few exceptions to the use of ether, only perhaps acute lung troubles, but, at first at any rate, better results will be obtained if the range of exceptions is somewhat enlarged.

In the fat and plethoric, . . .	Induce with A.C.E., and gradually increase the proportion of ether in long operations.
Acute or very recent lung troubles, .	Chloroform all through.
Chronic lung trouble (bronchitis or emphysema), ...	A.C.E. all through.
Organic heart disease, . . .	If insufficiently compensated (pulmonary œdema, anasarca, albumen, etc.), A.C.E. or chloroform. If fully compensated, ether permissible.
Marked Atheroma, ...	Induce with A.C.E.; add a little ether if the operation be a prolonged one.
Renal Disease, ...	A.C.E. all through.

Alcoholics take all anæsthetics badly. In acute or advanced cases it is, perhaps, better to commence with A.C.E., and gradually increase the proportion of ether as the case proceeds.

(5) **Nature of the Operation.**—To a great extent, the influence of the nature of the operation upon the choice of the anæsthetic, must be largely determined by the opinion of the surgeon upon the subject. It is, therefore, a point of no little importance that the latter should have complete confidence in the administrator. The careful selection of the administrator is a question of the greatest moment, and not to be dismissed lightly; to take any one that offers is very unjust to the patient, and accounts for many of the troubles and fatalities which are from time to time recorded.

Operations upon the head and neck,	A.C.E. to induce, increasing the proportion of ether in long operations.
Intra-cranial operations, . . .	Chloroform or A.C.E. all through.
Operations upon the tongue and mouth,	Induce with A.C.E.; change for chloroform directly operation commenced.
Operations on big joints, . . .	Always ether, if possible.
Abdominal operations, . . .	Do well with ether, but chloroform or A.C.E. often preferred by surgeons.
Rectal and genito-urinary operations,	Always ether, if possible.

In practice, the choice of the anæsthetic may be quickly determined by adopting a process of exclusion, taking the different substances in the order of their relative strength as given on p. 85. Commencing with Nitrous Oxide, the reasons for and against each drug may be rapidly worked out in accordance with the above tables.

Administration of Nitrous Oxide.

Properties.—The chemical constitution of Nitrous Oxide is sufficiently indicated by the formula N_2O. It is a gas, but is usually sold in a highly compressed, liquid form, in steel or iron bottles (Fig. 18, *A*). The gas, when pure, should be quite colourless, of a slightly sweetish taste and odour, and unirritating to the air passages. It is a feeble anæsthetic, and is usually given without any admixture with air, *i.e.* 100 per cent. of the vapour.

Cases Suitable.—Broadly speaking, anyone can take nitrous oxide with comparative safety. It is better, perhaps, not to administer it within an hour or so of a full meal, and care should be taken that the bladder is empty, especially in children, but otherwise, no special **preparation** is needed, beyond that which is necessary to ensure free respiration (see p. 84). It is most frequently given with the patient sitting straight up in a chair, with the head in such a **position** that the tongue does not slip back over the glottis; it may, of course, be given with the patient recumbent. For the cases in which it is specially applicable, see Sec. (1), p. 85. In dental work, and in operations about the mouth, it is usual to insert a prop of cork or wood between the teeth before applying the facepiece.

Although in some respects an ideal anæsthetic, there are many **limitations to its use**; the most important of these is that, owing to its feeble

anæsthetizing power, it is difficult to maintain the narcosis for any length of time, and practically, therefore, its administration is limited to cases in which the available anæsthesia which follows the single application of the facepiece will suffice. On an average, this represents between 30 and 40 seconds, but, with a little careful manipulation and an occasional supply of air, provided that the operation is not upon the mouth, this time can easily be doubled or trebled. But even in this short space of time much can be done, and, as the profession becomes more familiar with the drug, its field of usefulness will be found to be more extensive than is generally supposed. Another objection to it is, that the relaxation of the muscles is usually very transitory, and, when the inhalation is pushed, there may be actual spasm ; in moving stiff joints, therefore, it is of importance not to continue the inhalation for too long a time without admitting air.

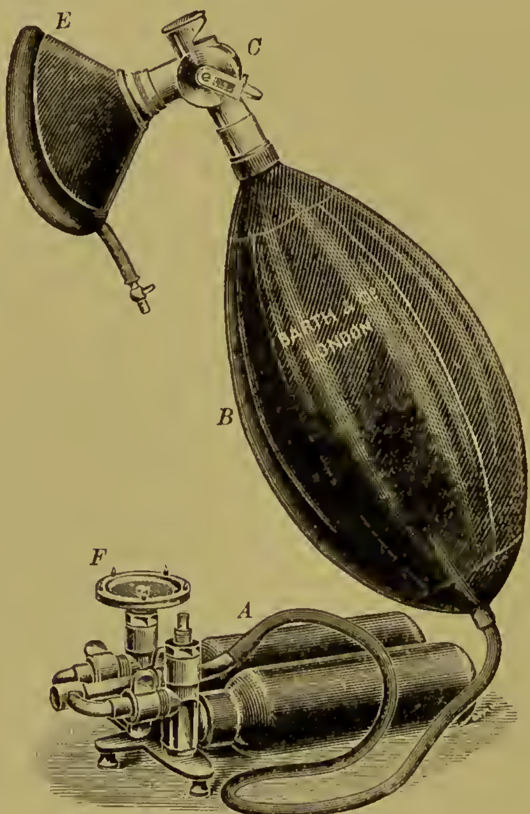

Fig. 18.—Nitrous Oxide Apparatus. *A*, Steel bottles containing compressed gas in liquid form; *B*, Reservoir bag; *E*, Facepiece; *C*, Three-way stop-cock containing inspiratory and expiratory valves; *F*, Footpiece for regulating escape of gas from the bottles into the reservoir bag.

Apparatus and Administration.—To ensure the complete exclusion of air, the somewhat complicated apparatus, shown and described in Fig. 18, is used. The bag *B* being filled with gas, the administrator stands either behind or on the left side of the patient, and carefully adjusts the face-piece *E* to the irregularities of the face. Being satisfied that there is no air leakage, the stop-cock *C* is turned on half-way; the nitrous oxide is then inspired from the bag, and expired through the valves contained in the stop-cock into the open air.

Phenomena.—After a very few respirations the colour of the face commences to change, becoming more and more dusky, or uniformly livid. Gradually, too, the breathing becomes harsher, and changes to a regular snore, which, in its turn, gives place to an irregular, jerky, **laryngeal stertor**; at or about the same time, or sometimes even before the laryngeal stertor is noticed, **twitching** of the superficial muscles of the eyelids, mouth, neck, etc., or of the tendons of the thumbs and fingers will be seen; and, if the inhalation were to be continued beyond this, well-marked jactitation of the limbs, or even opisthotonic spasm of the whole body, would result. Usually, but not always, the pupils dilate, and the conjunctivæ may or may not become insensitive to touch, but the eye reflex is not a reliable sign of the sufficiency of the anæsthesia. Whichever is first observed, the irregular laryngeal stertor, or the twitching of the muscles and tendons, is the indication for withdrawing the facepiece. After the facepiece has been withdrawn, the first few breaths of air are followed by a reactionary redness or blush about the face, etc., and this is an important landmark for the administrator; not until it occurs is he quite free from anxiety.

Complications.—The action of nitrous oxide is really remarkably uniform, and complications rare; but still it must be borne in mind that accidents have happened, and that deaths have occurred both from syncope and asphyxia. It should be a rule, therefore, to keep a finger on the temporal pulse, both during the inhalation, and until the reactionary flush occurs; if the pulse disappear, the patient should be at once put in the recumbent position, and the ordinary treatment for syncope adopted. Asphyxia may be due to a foreign body, *e.g.* a tooth, and it also seems likely to occur in patients suffering from a condition of more or less acute inflammation of the fauces and trachea. In asphyxiated patients, the first thing to do is to pass the finger well to the back of the throat to free the air-way, and to see if perchance a foreign body can be felt and removed. Failing this, the patient should first be bent sharply forward, and encouraged to cough by patting the back, etc.; if this does not give relief, he may be turned over on the side, and, if this fails, the question of tracheotomy, or better, laryngotomy will have to be considered. Hysterical patients sometimes give trouble by struggling and screaming; this is best overcome by compressing the reservoir bag, and so forcing the gas into the lungs, taking care, of course, to cut off the action of the valves in the stop-cock. Children and anæmic girls are apt to pass quickly and deeply under the influence of the gas, and to become opisthotonic; the facepiece, therefore, should be removed immediately the slightest twitching or stertor occurs.

The **after-effects** of nitrous oxide may be said to be practically **nil**, and this is one of its great advantages. Neurotic patients are sometimes hysterical, very rarely there is a little sickness, but, in by far the majority of cases, the patient is quite able to leave the house, or walk about within ten minutes or a quarter of an hour of the inhalation.

PROLONGED NITROUS OXIDE ANÆSTHESIA.—Various plans have, from time to time, been suggested for increasing the anæsthetising power of the gas. In operations not involving the mouth or nose, the anæsthesia may often be much prolonged by allowing the patient an occasional breath of air directly the twitching appears. In dental and other mouth cases, the supply of nitrous oxide may be maintained by means of a cap fitted over the nose, as suggested by Coleman and Patterson, or a tube may be passed into the mouth, or down

FIG. 19.—HEWITT'S APPARATUS FOR THE ADMINISTRATION OF NITROUS OXIDE AND OXYGEN. *A*, Steel cylinders containing compressed oxygen and liquid nitrous oxide; *F*, A double tube, one within the other, conveying the respective gases (O and N_2O) to the double reservoir bag *B* and *D*; *C*, Stop-cock by which oxygen is allowed to pass through minute holes at the same time that the nitrous oxide is turned on; *E*, Facepiece.

the nose, and connected with the reservoir bag, as proposed by Hillier and Coxon.[1]

Adopting the view that the lividity, muscular twitching, and some of the other phenomena are indications of asphyxia, or more properly speaking, of oxygen starvation, and assuming that these phenomena are always objectionable,

[1] See *Transactions of the Society of Anæsthetists*, vol. I., 1898.

it has been proposed to administer a mixture of nitrous oxide and oxygen. The quantity of oxygen required is very small, and the chief difficulty has hitherto been in designing a method and an apparatus for practical use. Dr. Hewitt, after much patient labour and many experiments, has produced the apparatus shown in Fig. 19. The facepiece being accurately adjusted, the nitrous oxide mixed with the oxygen from one or two holes is breathed from the beginning, and the amount of oxygen is cautiously increased by a hole at a time as the inhalation proceeds. The indications for removing the facepiece are a faint stertor, fixation of the eyeball, and insensibility of the conjunctivæ. The plan, excellent as it is, requires constant practice before anything like uniform results are obtained, and, in common with the other methods referred to, is open to the objection that unpleasant after-effects are more likely to follow, than is the case when nitrous oxide is administered in the manner suggested in the text.

In the above-mentioned plans, it is sought to prolong the inhalation of the feeble anæsthetic, nitrous oxide, by preventing the development of the asphyxial symptoms. A similar result may be obtained by mixing the gas with some other and more powerful anæsthetic, such as ether. This is what is known as the "combined" or "gas-and-ether" method of anæsthesia, which will be referred to after the administration of ether has been described (see p. 97).

Administration of Ether.

Properties.—The chemical formula of ethylic ether is $C_4H_{10}O$; it is sometimes known as sulphuric ether. It is usually recommended to employ only that made from absolute alcohol; but of late years many excellent brands have been placed on the market, and, if carefully selected, their use seems unobjectionable. The substance employed should have a specific gravity of ·720; it should be neutral to test-paper, and, on being burnt off or evaporated from a white surface, should leave behind neither colour nor disagreeable smell.[1] The so-called "anæsthetic ether" of chemists is intended only for local purposes (freezing), and should never be used for inhalation. The vapour of ether is highly inflammable, and even—when mixed with air or nitrous oxide—explosive. Its anæsthetic strength is such, that over 30 per cent. of the vapour is necessary to produce narcosis within a reasonable time (Snow, "On Anæsthetics").

Cases suitable.—For reasons into which it is unnecessary to enter, it is considered by many that ether can, and should be employed whenever an anæsthetic is called for; practically, the only exceptions which are then admitted, are those in which bronchitis, or some other more or less acute lung trouble is present, or when, as in operations about the mouth,

[1] A continuous decomposition is said to go on at the exposed surface of the liquid, the results being objectionable. To obviate this, it has been suggested that a small quantity of metallic mercury should be kept in each bottle; an insoluble black oxide of mercury is then formed, from which the pure ether can be decanted as required (Prof. Ramsay, *Soc. of Anæsthetists*, Nov., 1898). I have myself given this suggestion a prolonged trial. There can be no doubt as to the formation of the black oxide, but I am not quite convinced that the clinical value of the ether is improved.

it is either physically impossible to apply the facepiece, or else there is some danger that the actual cautery will ignite the vapour. For the reasons given above (see p. 85), this universal use of ether is at first likely to prove disappointing in the hands of those whose training and practice has not thoroughly accustomed them to the drug. When only occasionally called upon to anæsthetise, it is better for the administrator to limit his use of ether in accordance with the suggestions already made (see p. 86). If these lists be carefully studied, it will be seen that ether is *not* recommended for children under twelve, or for adults over sixty; nor for the fat and plethoric; nor for those suffering from gross cerebral lesions; nor in cases of lung disease; nor in acute heart disease, atheroma, or renal disease; nor in operations about the head and neck, mouth and tongue. At first sight, it may appear that this list of exceptions reduces the available cases

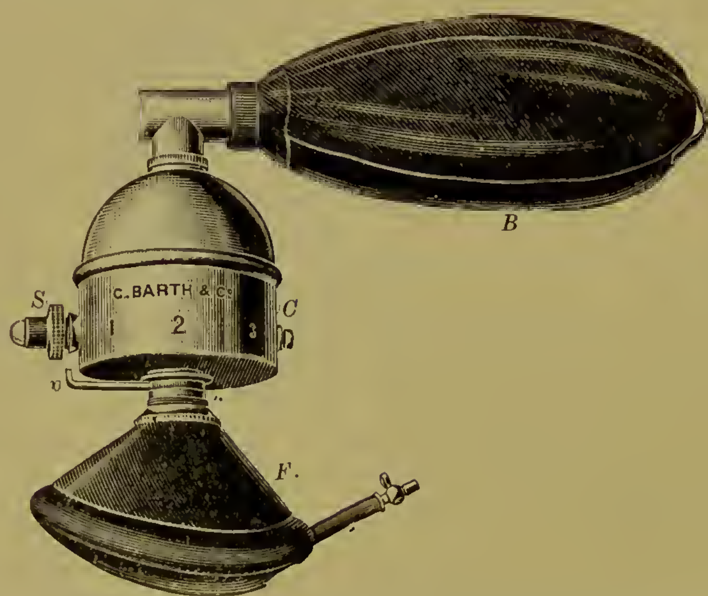

FIG. 20.—CLOVER'S SMALL OR PORTABLE ETHER APPARATUS. *C*, Ether chamber; *S*, Opening through which the chamber is filled with 2 ozs. of ether; *F*, Padded facepiece; *B*, Reservoir bag; *p*, Pointer or index, which is a fixture. To increase the proportion of ether inhaled, the chamber is rotated so as to bring the figures 1, 2, etc., over the index in succession.

to a minimum, but in practice this will not be found to be the case, and, further, it must be pointed out, that in by far the majority of cases the objection applies rather to the primary *induction*; in nearly all it is possible to use ether to *maintain* the anæsthesia.

Ether should always be given, if possible, in cases involving much shock, and in which a profound degree of narcosis is required, as in operations about the rectum, on the genito-urinary tract, or on big joints. Operations upon the abdomen are on the border-line, and the anæsthetic chosen must be largely determined by the predilection of the surgeon (see p. 85).

With regard to the **preparation** of the patient, nothing need be added to what has already been said upon the subject (see p. 82). It is

one of the advantages of ether which is sometimes overlooked, that, if need be, it can be administered to a patient sitting up, without very much additional risk; preference should, however, always be given to the recumbent **position**, as the increased muco-salivary secretion can then be got rid of more easily.

Apparatus and Administration.—In an emergency, an inhaler for ether can be made by twisting two or three folds of brown paper into a cone, like a grocer's sugar-bag, pinning the folds together, pushing a wide-meshed sponge well up into the apex of the cone, tearing off the extreme tip to admit air, and shaping the mouth of the bag to fit over the nose and chin; the ether is poured upon the sponge. Of course, better results will be obtained when a properly constructed inhaler is used. In Fig. 20 the well-known **Clover's** (small and portable) **Inhaler** is shown. Two ounces of ether are poured into the ether chamber through the opening *S*. The inner tube, with the facepiece attached, is thrust up through the corresponding opening in the ether chamber, the index *p* carefully adjusted to the mark 0 on the body of the chamber, and the facepiece *F* placed over the mouth and nose of the patient. After a few breaths have been taken, and the patient has become accustomed to the apparatus, the bag *B* is fixed on to the end of the tube which will be found flush with the upper opening in the ether chamber. A few breaths in and out of the bag are allowed, and then, during an expiration, the body of the chamber is gently rotated, either to the right or to the left, for the space of about a quarter of an inch, or even less; a few more breaths being allowed, another rotation of about the same extent is made. These movements are repeated at short intervals until, finally, the index points to about the 3, at which position it is maintained until a sufficiently profound degree of narcosis is obtained. Each movement of the ether chamber should be a little larger than that which immediately precedes it, should be made during an expiration, and no additional onward movement should take place so long as coughing, spasm, or other indication that the vapour is producing undue irritation is present. It is seldom, if ever, necessary to give a greater strength of vapour than that indicated above, and, in fact, when the primary skin incisions have been made, and the patient has become quiet, and saturated with ether, it is, in many cases, advisable to diminish the strength of the vapour by turning the ether chamber back to the 2, or even to the 1.

Another very useful and somewhat simpler form of apparatus is that known as **Ormsby's Inhaler**, shown in section in Fig. 21. In this inhaler the means for regulating the strength of the vapour, even approximately, are not very accurate, and, consequently, it requires some practice before it can be used with certainty. The great point is, to commence with only a drachm or two on the sponge at first, and to allow a free entrance of air through the valve and under the edge of the facepiece, until the patient becomes thoroughly accustomed to the drug.

For the sake of convenience of description, it is usual to divide the **process of anæsthetisation** into four stages, but, of course, it must be understood, that this arrangement is somewhat artificial; clinically, the different stages merge into and overlap one another, and are not equally well defined

Fig. 21.—Sectional View of Ormsby's Ether Inhaler. *B*, Padded facepiece, at the apex of which is fitted a wire cage (dotted line), for holding the sponge upon which the ether is poured. Over this cage and its contained sponge a large india-rubber bag, *A*, is fitted. At *C* is an arrangement which admits of a certain amount of regulation of the air-supply.

in every case. These stages are:—First, the stage of confusion of ideas, with subjective sensations of dizziness, tingling of the extremities, etc.; second, the stage of excitement and more or less struggling; third, the stage of anæsthesia, with flaccidity of the limbs, slow movements of the eyeballs from side to side, abolition of the conjunctival and other superficial reflexes, but the deeper reflexes are retained, so that there is still the power of coughing and swallowing, and, when the skin incisions are made the muscles are apt to be thrown into spasm; the fourth stage is characterized by more markedly stertorous breathing, dilated pupils, fixation of eyeballs, and abolition of all reflexes, both superficial and deep. As a general rule, the fourth, or most profound degree of anæsthesia, is kept up only until the primary incisions have been made, after which the patient may be allowed to fall back to the third degree; but in cases where con siderable shock is to be anticipated, as in operations upon the abdomen, on the large joints, in the genito-urinary areas, etc., it is of great importance that the anæsthesia should be maintained fairly deeply throughout.

There are three **special points** in connection with ether anæsthesia which must be noted. If the vapour be introduced too rapidly, or its strength increased too suddenly, some temporary *laryngeal spasm*, with more or less coughing and straining, will very likely ensue; if this does not disappear in the course of a few respirations, air must be admitted and the proportion of vapour diminished. It is generally possible to induce anæsthesia with but little alteration in the colour; for the first four or five minutes, however, some slight *lividity* is excusable, but it is quite a mistake to suppose that persistent and marked blueness is of necessity associated with the use of ether; such a condition means either bad administration, or that the patient is not a fit subject for this particular drug. Directly the colour commences to change, air must be admitted beneath the edge of the facepiece, and if, in spite of the free admission of air, the lividity persists, or sufficiently profound anæsthesia cannot be obtained, it is wisest to change the anæsthetic. The third point is, that as the patient passes under the influence of the vapour, there is a considerable *increase in the flow of mucus and saliva*; as soon, therefore, as the muscles of the neck become sufficiently relaxed, the head must be turned to one side, so as to encourage this excessive secretion to flow into the cheek, and so out of the mouth.

The essential characteristic of ether anæsthesia is the *stimulation*. The respirations increase in frequency and depth, and, partly on account of the presence of mucus in the air passages, they are usually noisy. The pulse becomes quicker, of greater volume, and improved in tone; an erythematous flush, (ether rash) often appears over the neck, chest, and arms, and may be so well marked, and so extensive, as to be mistaken at first sight for one of the exanthemata. The pupils are widely dilated during the stage of excitement and struggling, moderately contracted during the comparatively light anæsthesia of the middle of the third stage, but tending to dilate as the narcosis becomes deeper; unless this dilatation takes place very suddenly, it is not of necessity a sign of danger, as in the case of chloroform.

The chief **dangers** in connection with the administration of ether are of an asphyxial type. The muco-salivary secretions may be so excessive that the lungs may become "water-logged," the heart's action seriously embarrassed, and the venous system engorged. The careful administrator ought never to allow a patient to get into this serious condition; the free admission of air, or if this fails, the substitution of another anæsthetic should not be delayed when once the tendency is apparent. The accumulation of mucus may often be checked at the outset by permitting the patient to come round just sufficiently to allow of his swallowing, or even, when it is permissible, vomiting. If, however, the condition of "water-logging" has arisen the anæsthetic must be withheld, the mouth opened, the tongue pulled forward, the mucus sponged out from the throat, vomiting encouraged, and finally, the patient must be turned on his right side; it is

in such cases as these, that the administration of oxygen is especially called for. In the earlier stages of ether narcosis, primary cardiac syncope seldom if ever occurs as a direct result of the inhalation, although, of course, the mere dread of the operation may have this affect; on the other hand, cases are on record in which death, occurring at a later period, appears to have been due to over-stimulation of the heart, and, perhaps, of the respiratory centre. If, then, while the patient is well under, the breathing becomes more rapid and shallower, the inhalation should be suspended for a short time until the normal condition is restored.

With either the Clover's or the Ormsby's inhaler, the time occupied in producing anæsthesia must, of course, vary very considerably; from four to six minutes may be taken as a good working average. From a calculation based upon 277 cases, in which both the duration of the operation, and the quantity of ether used was noted, one ounce of ether was estimated to last, on an average, 10·95 minutes.[1]

After-effects.—If the patient has not been more than about a quarter of an hour or twenty minutes under the anæsthetic, he passes, on discontinuing the inhalation, through the stages already referred to (see p. 94), but in reverse order, viz., comparatively light anæsthesia, excitement, gradually returning consciousness. In any event, one of the first after-effects is usually the *vomiting* of mucus, often frothy and ropy, and frequently bile-stained. With ether, this is apt to be very severe during the first hour or two, but as the patient is but partly conscious, it is really less distressing to him than at first sight appears. As soon as he can do so, the patient should be encouraged to wash out his mouth with warm water, and sips of hot water should be swallowed. In some cases, especially if there has been little or no sickness, more or less violent *delirium* is observed. The frequency with which serious *pulmonary troubles* occur after the use of ether has probably been greatly exaggerated. On the other hand, there can be no doubt that the inhalation of ether renders the lungs particularly susceptible to alterations in temperature, draughts, etc. Consequently, some bronchial irritation may occasionally follow the inhalation. It is wise, therefore, to order that the temperature of the room should not be allowed to drop below 65° F., that screens should be placed round the bed, and that for the first few hours at any rate, the patient should, if possible, be kept lying on one side, by preference the right. This latter manœuvre not only assists the escape of saliva, etc., from the mouth, but, I believe, also facilitates the onward flow of the mucus, etc., through the pylorus, and so diminishes the tendency to retching and sickness. Occasionally, "water-logging," and the effects of over-stimulation (see p. 95) do not manifest themselves until after the patient has been put back to bed, and fatal results have been recorded from these causes at this stage; patients should, therefore, be strictly watched by a responsible person, for at least an hour or more after the

[1] *King's College Hospital Reports*, Vols. II., III., and IV.

completion of the operation. For a more detailed reference to after-treatment see p. 116.

Nitrous Oxide and Ether Combined.—The so-called COMBINED METHOD is the plan of inducing anæsthesia with nitrous oxide, and maintaining the narcosis with ether (nitrogenizing the ether). The procedure is as follows, viz.:—If the Clover's inhaler be used, the three-way tube and bag of the nitrous oxide apparatus are substituted for the smaller ether-bag (Fig. 22).

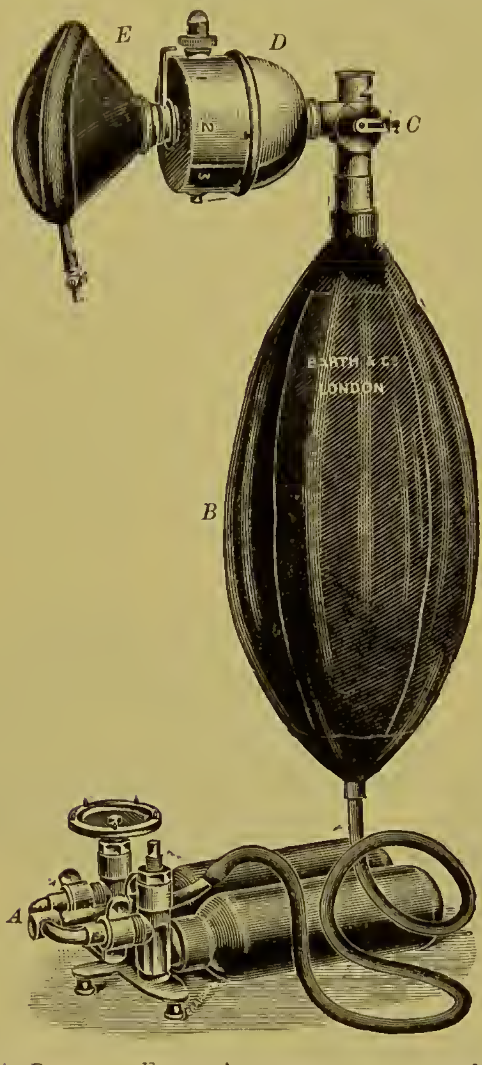

FIG. 22.—CLOVER'S PORTABLE ETHER APPARATUS, FITTED FOR NITROUS OXIDE AND ETHER COMBINED. *A*, Steel gas bottles; *B*, Reservoir bag; *C*, Three-way stopcock connecting gas bag; *D*, Ether chamber; *E*, Facepiece.

About half a dozen full respirations of the nitrous oxide are allowed, and then the ether vapour is cautiously admitted by rotating the ether chamber. When once the ether is tolerated, the increase in the strength of the vapour may be much greater, and made at shorter intervals than when ether alone is being administered. When irregular stertor and twitching of the muscles appear, the nitrous oxide must all be pressed out of the bag, and a breath or two of air given, or perhaps a better plan is to change the large for the smaller bag at this stage. If the Ormsby's inhaler be used for the ether, the patient is first anæsthetised with

the apparatus figured on page 88, and directly the irregular stertor and twitching appear, an Ormsby's inhaler, fully charged with an ounce of ether, is rapidly substituted, without permitting any fresh air to be breathed ; the spasm caused by the excessive strength of ether vapour is sometimes very pronounced, but will quickly pass off, and the patient will rapidly come under the influence of the ether. Except in the hands of an adept, this use of the Ormsby's inhaler is difficult, and even when the Clover is employed, a good deal of practice is required before uniformly satisfactory results are obtained. The point to be aimed at when using the latter apparatus is the turning on of the ether at such a rate, that a full dose is being inhaled at the precise moment when the muscular twitching, etc., due to the nitrous oxide, are first observed.

It is claimed for these combined methods that they are far more pleasant for the patient, as he is unconscious of the irritating and disagreeable taste and smell of the ether ; that they are much more rapid, induction only occupying about two minutes as compared with four to six minutes when ether alone is used ; that to a great extent they do away with, or considerably modify the excitement and struggling, and so enable us to dispense with the help of others in restraining the patient. That substantial advantages are to be gained by adopting one or other of these plans, is sufficiently proved by the fact, that there are probably but few anæsthetists of the present day who do not employ them, or who habitually use ether alone.

Ether is also frequently used in dental work for the purpose of intensifying the action of nitrous oxide (etherizing the nitrous oxide). The Clover's apparatus may be used for this purpose, and the procedure is practically the same as already detailed, except, perhaps, that the patient is allowed to get more fully under the influence of the nitrous oxide before the ether is turned on, and the ether is turned on more rapidly. It is for these cases that the large Clover (Fig. 23) is particularly

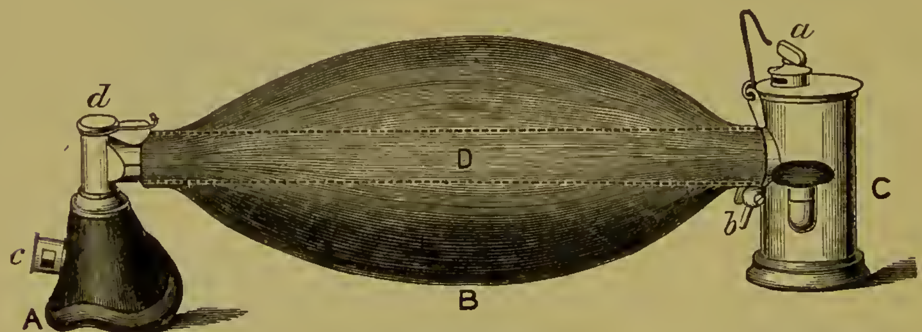

Fig. 23.—Clover's Large Nitrous Oxide and Ether Apparatus (modified). *A*, Facepiece; *c*, Expiratory valve; *C*, Ether chamber ; *a*, Stopcock for bringing ether chamber into connection with the tube *D*, which in its turn communicates with the facepiece. *B* is a reservoir bag which may also be used for nitrous oxide alone, being filled with gas through the tap, *b*. When it is desired to administer ether and nitrous oxide in combination, the bag is filled with gas, the tap *a* is turned on, and the amount of ether supplied is regulated by means of the tap *d*.

useful, as the odour of ether can be more perfectly shut off from the facepiece, and does not diffuse itself into the room. I believe myself, that in this use of ether the local effect of the vapour upon the buccal mucous membrane, is largely responsible for the prolongation of the anæsthesia.

Administration of Chloroform.

Strictly speaking, one ought now to describe the administration of diluted chloroform in the shape of the mixtures (A.C.E., etc.), as these rank next above ether in anæsthetic strength. For convenience in description, however, and to avoid repetition, chloroform anæsthesia will first be referred to.

Properties.—Chloroform has a chemical formula of $CHCl_3$. Its *spec. grav.* should be 1·497, and only that made from pure alcohol should be employed; the so-called methylated chloroform is inadmissible for anæsthetic purposes. Unless carefully protected from heat and sunlight, it is apt to decompose.[1] It should be quite colourless; neutral to test paper; leaving no disagreeable smell or coloured residue on evaporation; giving no precipitate with a solution of nitrate of silver; and not turning brown on mixing with an equal volume of pure sulphuric acid. The vapour is upwards of four times as heavy as air, uninflammable, but decomposing into highly irritating gases when passed through or brought into contact with a flame. Hence it is important, when operating at night, or in small rooms in the presence of a naked flame, to secure a full and adequate amount of ventilation. Chloroform is the strongest anæsthetic that we possess; above 4 per cent. of the vapour constitutes a dangerous dose.

With nitrous oxide and with ether, special means have to be adopted to obtain a sufficient percentage of the vapour; with chloroform, on the other hand, the greatest attention must be paid to securing a sufficient supply of air.

Cases suitable.—If the suggestions already made (see p. 85) as to the alternative use of the several drugs be adopted, it will be found that the use of undiluted chloroform will be limited to such cases as the following, viz.—Infants, and very young children of one or two years of age; those suffering from acute or very recently acute lung trouble; in parturition, where only a partial action seems to be required; in operations about the nose and mouth, to maintain the anæsthesia induced by other anæsthetics; in proximity to the actual cautery, etc. Chloroform enters largely, however, into the composition of the A.C.E. and other mixtures, so that practically it still retains a prominent place in the list of available anæsthetics.

The **preparation** of the patient should be carried out strictly on the lines suggested on p. 82, and, with regard to **position**, an emphatic protest must be entered against any attempt being made to administer chloroform to a patient sitting in a chair. This protest is necessary, because it is still occasionally used for tooth extraction with the patient in the ordinary

[1] The products of decomposition, as far as they are harmful, are said to be neutralised if a small quantity of slaked lime be kept in the chloroform bottle, the pure chloroform being decanted off as required. I have not, however, any personal experience of the value of this proceeding.

dental position. When chloroform is inhaled the patient should always be recumbent.

Apparatus and Administration.—The simplest way to administer chloroform, and at the same time ensure a sufficient supply of air, is to sprinkle it *drop by drop* by means of a suitable drop-bottle (Fig. 25), on to the outside of a folded **towel** (Fig. 24), or on to a handkerchief, or, better still, on to a piece of domette stretched tightly over a metal frame (**Skinner's**

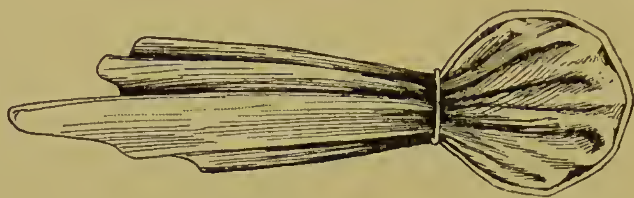

Fig. 24.—Towel folded for the Administration of Chloroform.

Fig. 25.—Graduated Drop-Bottle with Hollow Stopper.

Fig. 26.—Skinner's Frame.

Inhaler), Fig. 26. Personally, I strongly object to the use of lint, the woolly surface of which quickly becomes sodden, and renders the equable distribution of the vapour almost impossible.

By some, the **Junker's Inhaler** (Fig. 27) is preferred. The principle of this apparatus is simply that of blowing air through a layer of liquid chloroform by means of a hand-bellows, the mixture of air and vapour being conveyed to a facepiece. Variations in the strength of the vapour are determined by the force and frequency with which the bellows are pressed. Care must be taken that the liquid chloroform does not more than half fill the bottle, and that the bellows-tube and the exit-tube are fitted to their respective metal connections. Fatal accidents have occurred from neglecting these points, as liquid chloroform is then poured into the patient's mouth.

Whichever method be employed, it must be constantly borne in mind that **care and vigilance**, on the part of the administrator, are much more important elements of success than is the use of any particular apparatus. Excellent results may be obtained by any plan that is systematically studied and employed.

With chloroform, as with every other anæsthetic, it is very important to **commence** the inhalation **gradually**. The evaporating surface must, at first, be held some four or five inches from the face, and only brought close over the nose and mouth as consciousness is abolished and toleration established. If, as may sometimes happen even in the earlier stages, there be any retching, the anæsthetic should be pressed, when the retching will often cease; but if vomiting has actually taken place, and the contents of the stomach have regurgitated into the mouth, the anæsthetic must be

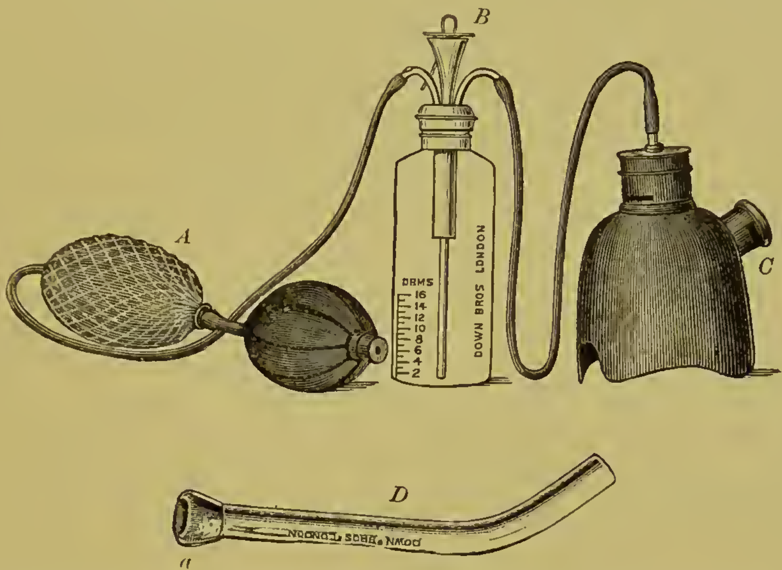

Fig. 27.—Junker's Apparatus for the Administration of Chloroform. *A*, Hand-bellows for forcing air through the chloroform contained in the bottle *B*, and thence into the vulcanite facepiece *C*. *D*, Mouth tube for use with Junker's Apparatus; the facepiece *C* is removed and the end *a* of the tube is slipped on to the rubber pipe.

withdrawn, the mouth opened, and the vomited matter removed. The stage of excitement and unconscious struggling requires careful management. The condition of mental and physical turmoil is undoubtedly a dangerous one, and should not be allowed to become unduly prolonged. On the other hand, the deep inspirations which the patient sometimes takes are apt to overcharge the lungs with vapour, and so to lead to sudden respiratory and circulatory failure. The best plan, I believe, is to give the anæsthetic freely at these times, but making sure, by raising the inhaler, etc., that the amount of air is proportionately increased. It is dangerous, with chloroform especially, to bring the inhaler closer to the face while struggling is proceeding.

The **phenomena** observed during the induction of anæsthesia with chloroform, are very similar to those already alluded to in describing ether anæsthesia (see p. 94). The stage of excitement is perhaps less marked

and of shorter duration, and it is followed by a period of depression, in which the blood pressure falls, the pulse becomes smaller and weaker, and the respirations shallower. During the stage of excitement the *pupils*, as a rule, dilate rather widely, and this dilatation may continue, especially in young children and in the neurotic, for a considerable length of time, if not during the whole period of narcosis; usually, however, the pupil during the third stage is moderately contracted, *i.e.* rather smaller than with ether. During the fourth stage, the pupil tends to dilate, often suddenly, and this is an indication that the narcosis is of dangerous depth. Then, again, a rather widely dilated pupil is often the precursor of vomiting, which cannot of course occur unless the patient be but lightly anæsthetised. These alterations in the size of the pupils, when rightly interpreted, afford valuable information to the administrator, but at the same time it is obvious, that we cannot rely upon the pupil phenomena alone as indications of the exact state of the patient. Occasionally during induction, and especially in children, the patient passes imperceptibly into a curious and anomalous condition of anæsthetically induced sleep, or *false anæsthesia*; the pupils are sharply contracted, the limbs are quite flaccid, the superficial reflexes abolished, and it is not until the deeper reflexes are excited, as by the skin incision, that we are able to recognize the fact that the state is in reality one of light anæsthesia.

The ideal condition of a patient under chloroform should be somewhat as follows, viz.: colour good, or slightly pallid; respirations regular, fairly deep, slightly accelerated, quiet, or with a slight, soft snore; eyeballs fixed or rotating very slowly from side to side, pupils moderately contracted and sluggishly sensitive, corneal conjunctivæ insensitive. The greatest variations from this standard will be found in the very young and the very old—in old people the respirations and pulse rate may both be very much below the average. It is impossible, however, to refer in detail to all the variations which may be observed. Very occasionally in quite young infants, an undue strength of vapour will give rise to some slight laryngeal spasm. Blueness of the lips, cheeks, ears, etc., is quite unwarranted, as it indicates that the vapour is being given in far too great a strength, and air must at once be supplied; some patients become very pale under any anæsthetic which contains chloroform, and, if this pallor is gradually displaced by an ashy-grey hue, it is an indication that the circulation is failing, and the anæsthetic must be at once withdrawn, and, if need be, more energetic measures taken (see p. 112). *The respirations must be watched with the greatest possible vigilance*, and variations in the rapidity and depth should be detected early. Quick, shallow breathing may end in total cessation of respiration, and is an indication for diminishing the strength of the vapour, or even withdrawing it for a time altogether. The treatment to be adopted when the breathing does stop will be described presently (see p. 112).

Pure chloroform, unmixed with ether, should not, theoretically, give rise to noisy or stertorous respirations, and certainly noisy breathing which

cannot be rectified by slight changes in the position of the head, pushing forward the base of the tongue, by pressure upon the angles of the inferior maxilla or lifting the chin upwards, must not be allowed. There is practically no increase in the flow of mucus, etc.

The essential characteristic of chloroform anæsthesia is the *depression.* Thus, paralysis of the respiratory centre is probably the most usual cause of death in fatal cases, though cardiac failure is not unknown. This tendency to respiratory failure sets in very early, and makes it more than usually imperative that the respiration should be most carefully watched, at the same time as, but even more vigilantly than the circulation. It is probable that respiratory failure is usually associated with cardiac failure, though not always *pari passu.* As Lord Lister has pointed out,[1] the breathing may become obstructed by the falling together of the relaxed soft tissues about the air passages, and this condition has an important bearing upon the treatment, as will subsequently be explained (see p. 110).

On an average, between six and eight minutes is a fair time to allow for inducing anæsthesia with chloroform by the above method. It is said by some, that the quantity of chloroform used should be at about the rate of ʒi. for every ten minutes of anæsthesia, but such estimates are unreliable, as it is obvious that the amount must vary enormously in accordance with such opposite conditions as the age of the patient, his state of health, the heat of the weather, the thickness of the towel, etc., etc.

The special **after-effects** of chloroform differ in degree rather than in kind from those observed as a consequence of the use of ether. The vomiting may not be so severe, but it often does not set in until consciousness is more or less completely restored, and therefore the feeling of wretchedness is prolonged. Bronchitis and other lung affections are rare sequelæ to chloroform inhalation, nor is delirium at all frequent. For a more detailed account of after-treatment see p. 116.

Administration of Mixtures (A.C.E., etc.)

From the point of view of anæsthetic strength, the mixtures occupy a position intermediate between ether and chloroform. Of such mixtures there may, of course, be an infinite variety, according to the relative proportion of the constituents, but to certain stock mixtures definite names have been attached; thus, a combination of one part of chloroform to three of ether is known as the "**Vienna mixture,**" while "**Billroth's mixture**" consists of three parts of chloroform, one of ether, and one of absolute alcohol. In this country, however, "**the A.C.E. mixture,**" or, as it is often called, "the mixture," is the term by which is usually indicated a fluid composed of absolute alcohol *spec. grav.* ·795 one part, chloroform *spec. grav.* 1·497 two parts, ether *spec. grav.* ·720 three parts; it is usually looked upon as merely a mechanical mixture of its constituents.

[1] Holmes' *System of Surgery*, vol. III.

Properties.—Its *spec. grav.* when freshly prepared, is as nearly as possible the mean of its three constituents, *i.e.*, 1·0; the *spec. grav.* of its vapour has not been experimentally determined. The particular purpose served by the alcohol is not very clear; possibly the advantage is mainly mechanical, leading to a more intimate admixture of the several constituents, but it is also claimed that the evaporation of the ether is somewhat retarded, and there is no doubt that, by the use of alcohol, the vapour inhaled has a pleasanter and less pungent smell than when ether and chloroform are alone employed. It is said to be somewhat unstable, and it is always recommended that it should be freshly prepared, as required.

Advantages.—The question is often asked, why the mixture should be preferred to pure chloroform. The reply to this query is founded partly upon theoretical, partly upon practical considerations. Theoretically, I am inclined to believe that the stimulating effects of the ether vapour, however slight, cannot but be of service, and that, by using a moderately diluted vapour, there is much less risk of overstepping the narrow margin of safety which is so characteristic of chloroform anæsthesia. Practically, I am sure that, with the mixture, one obtains earlier notice of impending danger than with chloroform alone. Neither the mixture nor any of the anæsthetics at present known are absolutely safe, but the danger with the A.C.E. is chiefly that of over-narcosis pure and simple, and of this more ample warning is given than with chloroform; to a great extent, though perhaps not entirely, the element of sudden over-dilatation of the heart is eliminated.

Cases Suitable.—Broadly speaking, it may be said that when, for any reason, neither nitrous oxide nor ether are considered advisable, the next string to the bow of the anæsthetist is the mixture. The list of objections to the use of ether, therefore, given on p. 92, constitutes a list from which cases suitable for the use of A.C.E. can be selected. But even the small amount of ether contained in the mixture may be considered harmful in infants and very young children; in those actually suffering from extensive lung disease, or when the actual cautery is to be employed in close proximity to the inhaler. As an inhaler is usually employed, it is not easy to maintain the narcosis with A.C.E. in operations about the mouth and nose, though even in these, the anæsthesia may easily be induced by this means.

The **preparation** of the patient should be carried out on the lines suggested on p. 82, and no **position** is permissible but the recumbent, or one in which the feet and legs are elevated to at least the level of the body.

Apparatus and Administration.—No form of closed or bag-inhaler of the Clover or Ormsby type must be used for A.C.E. or other chloroform mixture. In very small children, and in neurotic adults it may be given by the open method, *i.e.*, by dropping on the corner of a towel or handkerchief held just above the mouth. Generally speaking, however, an inhaler of the shape represented in Fig. 28 is desirable. It is important that a very free supply of air should be available, so the ventilation holes must be large and

numerous, and the facepiece ought not to fit over the nose and mouth with any great accuracy, and for this reason a padded facepiece is objectionable. In the actual administration two points are to be particularly attended to, viz.: Use small quantities of the mixture frequently repeated, rather than one or two large doses. By this means, the stimulating effects of the ether are more nearly continuous than when a large quantity of the liquid is used at a time. Secondly, in this, as in all other methods of inducing general anæsthesia, it is important to commence the inhalation very gradually, holding the facepiece a few inches from the face to begin with, and gradually bringing it nearer as the vapour is better tolerated.

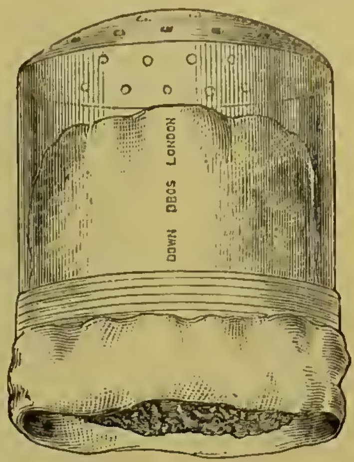

FIG. 28.—CELLULOID MASK FOR A.C.E. Fitted with a bag of thin flannel or domette in which is placed a full-sized, open-meshed sponge. The air holes at the end should be numerous and large. The flannel bag and sponge should be changed after each case, and the whole washed in *cold* water. In practice, the flannel bag should be much longer than is here represented, and should go well to the bottom of the inhaler.

The chief **objections** which have been urged against the use of the mixture are as follows, viz.: In the first place, it is sometimes said that an over-strong vapour, consisting chiefly of chloroform, is apt to accumulate in the mask below the sponge. The possibility of this occurring cannot be doubted, and the remedy is equally obvious. The mask must not fit the face at all closely, and must be supplied with plenty of large air-holes, and the anæsthetic must be added in small quantities (ʒi. to ʒii.) at a time. Under this head, too, must be included the objection, that the different constituents of the mixture evaporate at different temperatures. This, of course, is true, but experience has shown that the consequent slight variations in the composition of the vapour do not militate against the practical efficacy of the mixture. In the second place, it is objected that the sponge, flannel bag, etc., are liable to become over-saturated, especially in long cases, and the superfluous liquid is then apt to trickle on to the face and excoriate the skin. Here, again, by a little judicious management, the trouble can frequently be avoided. Add the mixture in small quantities at a time, as required, allowing a few seconds for it to soak well into the sponge; do not use old, hard sponges, but large soft ones, taking care that they are well washed after each administration; in long cases, too, the sponge should be changed from time to time. If the flannel bag be objected to it may be removed, and the sponge held in place by means of a wire passed transversely through two opposite air-holes. Perhaps a better and more cleanly form of inhaler is the metal mask figured on p. 106 (Fig. 29). This apparatus is made of metal, and can be purified in lotions or by heat. The sponge is retained in position by means of a wire guard Fig. 30 (*B*) and a shield set at an angle (*A*) prevents the liquid from running on to the face. The hinged, perforated, concave top (*D*) is convenient for charging

without removing from the face. Anæsthesia may be *maintained* with ether in these masks, if necessary, but it is difficult and often impossible to use them for the *induction* of ether anæsthesia.

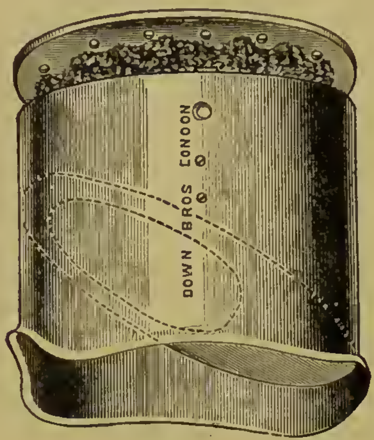

Fig. 29.—Metal Mask for A.C.E. or Ether.

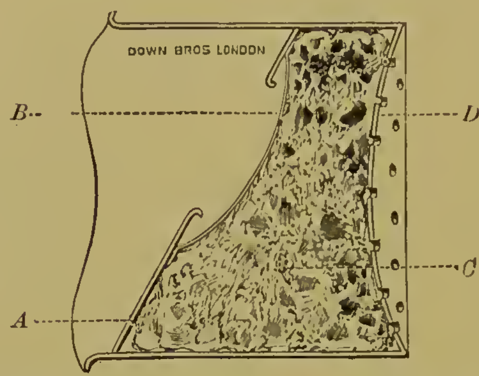

Fig. 30.—Sectional View of Metal Mask, shewing *A*, Shield or drip-catcher; *B*, Wire sponge guard; *C*, Sponge; *D*, Perforated hinged concave top.

Bearing in mind that the most potent constituent of the A.C.E., and most other mixtures, is the chloroform, it is only natural that the **phenomena** observed, and the precautions to be adopted in their administration, are but modifications of those already described under the head of the latter drug. Owing to the stimulating effect of the ether, which should be almost continuous if small, frequently repeated doses, mixed with plenty of air be given, the depressing effects of the chloroform are less apparent. On the other hand, laryngeal spasm is of slightly more frequent occurrence in children, and as the flow of mucus is increased, the breathing is apt to be a little more noisy. The ether-rash (see p. 95) is occasionally observed, and the pupils are, on the whole, inclined to be rather more widely dilated than with chloroform in the third stage of anæsthesia.

The dangers and after-effects are essentially those of chloroform (see p. 103), but as they are rather more gradual in their onset, they can usually be detected before the condition of the patient becomes serious. There appears to be less fear of early cardiac syncope.

As a rule, about an ounce should amply suffice to induce anæsthesia in most patients, and in children rather less will be required. From five to seven minutes should be allowed for the production of the primary narcosis. From a calculation based upon 988 cases in which both the duration of the operation and the amount of mixture used was noted, one ounce of A.C.E. was estimated to last on an average 17·76 minutes.[1]

ETHER PRECEDED BY A.C.E.—When, for any reason, nitrous oxide is objected to as a vehicle for introducing ether by the "combined method" already referred to on page 97, the A.C.E., given on a towel, a handkerchief, or in a mask, may be substituted for the gas with advantage. But very little mixture is necessary for this purpose (ʒi.-ʒii.), the anaesthesia is not carried

[1] *King's College Hospital Reports*, vols. II., III., and IV.

much beyond the end of the first stage, just sufficient to abolish consciousness and stopping short of the stage of excitement ; a fully charged ether inhaler is then substituted. In cases lasting more than half-an-hour too, I am in the habit of increasing the proportion of ether until, at last—after about an hour—ether alone is inhaled, the same mask being used throughout.

Special Cases.

Under certain conditions, some slight departure from the ordinary routine methods of administration seems to be desirable, but space will not permit of more than a passing reference to these cases, and this reference may most conveniently take the form of indicating my own practice in the matter.

In intra-cranial operations I usually advise the preliminary injection of a small dose of morphia ($\frac{1}{6}$ to $\frac{1}{4}$ gr.). Anæsthesia is induced in the recumbent position, and the body is raised slowly and cautiously to an angle of about 45 degrees. Chloroform or the A.C.E. is used throughout, and only just enough anæsthetic is given to keep the patient quiet. His disease and the effects of the morphia combined, render him very susceptible to an over-dose, and at the same time make him less susceptible to actual pain.

Operations about the Nose and Mouth.—In such short operations upon the nose as the removal of spurs on the septum, turbinated bodies, etc., the operator often considers it better for the patient to be sitting up, in which case, of course, nitrous oxide, with or without the addition of oxygen or ether, is the best anæsthetic, and as soon as possible the body should be pushed well forward, so that the head may hang over a basin placed between the knees, when the blood will run out of the nose and mouth. A somewhat similar position and procedure will, in the opinion of some surgeons, suffice for the removal of tonsils or adenoids, but when the choice is left to the anæsthetist, I must confess that I have a preference for the plan of lightly anæsthetising the patient in the recumbent position with A.C.E., and turning him on the right side as the operation proceeds.

Use of Junker's Inhaler with Tube.—In long operations about the buccal cavity, *e.g.*, removal of the tongue, I prefer to induce anæsthesia to a tolerably profound degree with A.C.E., and to maintain it with chloroform given out of a Junker's inhaler (Fig. 27) in which the facepiece has been removed and a tube substituted. The tube (Fig. 27 *D*) should have an internal diameter of at least four millimetres (they are generally much too narrow), and may be passed down the nose if necessary. Some administrators prefer to very thoroughly saturate the patient with ether for five or six minutes before the operation is commenced, and then, if need be, continue with chloroform. My own experience is that ether causes undue congestion and bleeding, and the increased flow of mucus still further obscures the field of operation, and increases the tendency to asphyxia. The practice of different surgeons varies considerably in respect to the **position** adopted for the performance of these operations. Many surgeons

prefer that, whenever possible, the patient should be absolutely recumbent, the head being allowed to hang over the end of the table, with the neck extended, so as to bring the post-nasal space into a dependent position. Personally, I am doubtful whether much is really gained by this, and I am quite sure that the bleeding is more profuse, and that the stretching of the muscles and tissues of the neck causes much after-discomfort. Others, again, like to have the head and shoulders well raised, and perhaps the chin strongly flexed towards the sternum. There are still others who place the patient sitting almost bolt upright. As an anæsthetist I am convinced that the latter is a most risky position, as it tends to encourage syncope; the other positions are not objectionable from this point of view. In such delicate operations as those for cleft palate, the dorsal position, with the head more or less extended, is imperative, so that the best view possible of the parts may be obtained. In these cases, too, some surgeons of great experience consider that healing is retarded by the direct impact

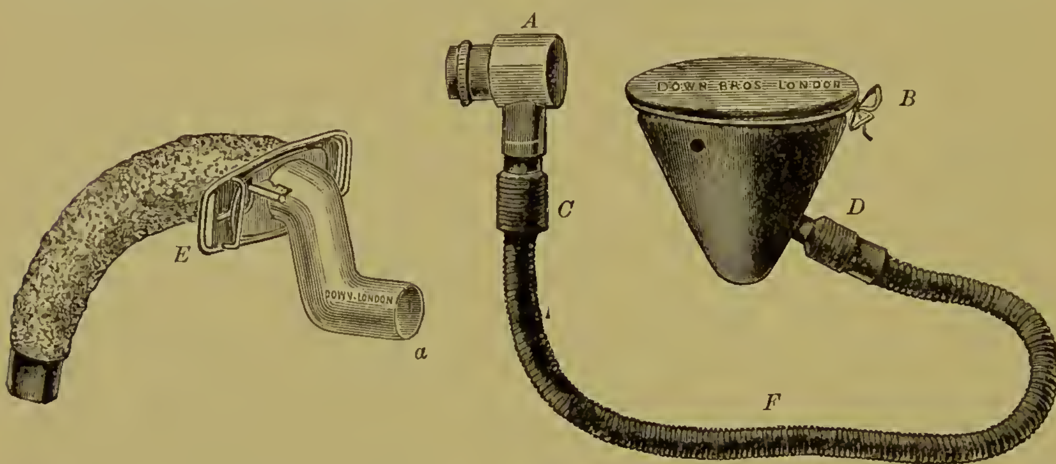

FIG. 31.—HAHN'S TRACHEAL TAMPON AND CHLOROFORM ATTACHMENT. *E*, Tracheal tube, covered with sponge which swells up in the trachea. *B*, Metal cone covered with domette on which the chloroform is dropped. *D*, *F*, *C*, *A*, Tube conveying vapour to tracheal tube on which it is fixed at *a*. It is of importance that the junctions *D*, *C*, and *A* be sufficiently large (for adults 6-8 mm.); in the tubes sold they are often much too small.

of the chloroform vapour from the tube upon the freshly cut edges of the wound, and they prefer to maintain the anæsthesia by means of chloroform dropped upon a towel or lint; but direct impact of the vapour ought to be easily avoided, and when this is done it is difficult to understand why, if the patient be kept well under, the use of the towel or lint should be less injurious.

In using the Junker's apparatus where the breathing is likely to be obstructed, it is important to bear in mind, that the heavy vapour of chloroform is apt to accumulate at the back of the throat, directly the breathing becomes in the slightest degree obstructed, so that the energy with which the bellows should be worked must be directly proportionate to the freedom of respiration.

In extensive operations upon the base of the tongue, etc., when **preliminary tracheotomy** is advisable, a Hahn's or Trendelenburg's tampon is

inserted (Fig. 31), the anæsthesia being then maintained through the tracheal opening.

Patients with **enlarged thyroids** are very liable to sudden attacks of syncope while taking anæsthetics, but, on the other hand, it is really remarkable what a very small quantity of anæsthetic will suffice to keep such patients thoroughly under. In thyroidectomies, therefore, I frequently use a Junker's apparatus throughout, giving but very little of the anæsthetic, only just enough to restrain the retching and vomiting to which such patients appear to be particularly prone. Abroad, local anæsthesia in the shape of cocaine is largely employed in these operations, but it appears to me to be quite possible, that the success of this drug in these cases is in some measure due to the difference in the type of the patients, as compared with those seen in this country.

In all these operations about the head and neck, some trouble is experienced in preventing the hair from falling into the wound, and in keeping the blood from the hair. I have adopted the device shown and explained in Figs. 32 and 33.

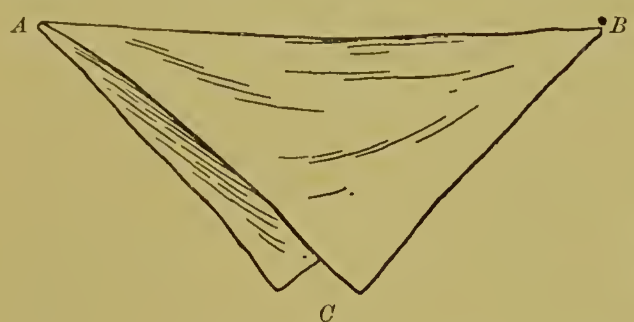

FIG. 32.

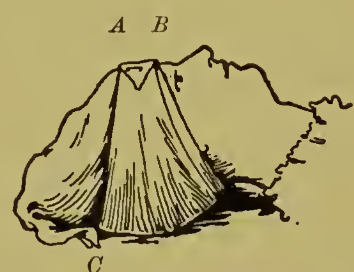

FIG. 33.

FIGS. 32 and 33.—PROTECTION OF THE HAIR IN OPERATIONS ABOUT THE HEAD AND NECK. The middle of tbe folded edge of a carbolised towel (Fig. 32) is placed over the forebead, carried down over the ears, the ends *A* and *B* crossed behind the occiput, and then brought over the forehead again. The points *C* may be used for including the stray ends of hair. The appearance will be as in Fig. 33.

In **severe operations** in which much shock is to be anticipated, it is of importance that the anæsthesia should be tolerably profound throughout. Among such operations I would particularly enumerate those affecting the big joints, those involving manipulation of the spermatic cord, operations upon the genito-urinary and rectal areas, and abdominal operations. When patients are losing much blood, or are suffering from primary shock or much prostration, the strength of the vapour inhaled may be considerably diminished.

Alcoholics are troublesome subjects to anæsthetize. They are apt to struggle very violently, to become very livid, and unless reduced to a dangerous degree of narcosis, they are often very restless. This is especially the case when ether is used. Their tissues are often much degenerated, so that in choosing an anæsthetic for such patients it must be remembered that they are prematurely aged. Acute or far advanced cases should perhaps be started with A.C.E., and ether gradually added.

Difficulties and Dangers.

Difficulties and dangers directly connected with the anæsthetic, are due to the effects of the various drugs upon either the respiratory, or the circulatory systems. Many and bitter are the controversies which have arisen as to which system is primarily affected, but much of this discussion has been of an academic rather than of a practical character; at present, the balance of opinion appears to be in favour of ascribing to both functions some share in the production of fatal results. At any rate, it is admitted on all hands that the depression in the respiration, even if it is not absolutely coincident with the circulatory failure, precedes or follows it so closely that, clinically, it is almost impossible to distinguish between the two effects, and, therefore, the line of treatment must be such as will give relief in both directions.

Simple **syncope** appears to be an accident to which patients are occasionally liable in the very earliest stages of the inhalation. Some such cases are undoubtedly due to mere fright, and can hardly be ascribed to the toxic effects of the anæsthetic; but, on the other hand, many cases are on record in which no such dread of the operation existed, but where, nevertheless, the patient, often a strong healthy adult, has suddenly succumbed after inhaling the anæsthetic for a few minutes, when apparently unconscious, and passing into the third stage (see p. 94).

In origin, **respiratory troubles** may be spasmodic, asphyxial, or due to the toxic effects of the drug upon the central nervous system. **Spasm of the glottis** may occur with any anæsthetic, but especially with ether when the vapour is too suddenly applied, or increased in strength too rapidly; the treatment, namely, withdrawal or diminution in strength of the vapour, is obvious, and no further reference need be made to it here. The irritation of the ether vapour may sometimes cause a good deal of coughing, and if this does not subside in the course of a few minutes, the inhalation of a few drops (10–20) of chloroform will often have a good effect, and the ether inhaler can subsequently be re-applied. **Asphyxial symptoms** are usually associated with marked lividity and gasping for breath, and may be due to a variety of causes, such as the presence of foreign bodies (false teeth, detached nasal polypi, etc.), to excessive flow of mucus, to blood, to extraneous pressure upon the trachea, to falling back of the tongue over the glottis (sometimes termed "swallowing the tongue"), etc., etc. Under this head, too, may be included those cases described by Lord Lister, in which the soft structures at the back of the throat fall together like curtains in front of the glottis.

Respiratory paralysis.—Of course, under the above circumstances, whether syncopal or asphyxial, the breathing tends to fail; but when we speak of "failure of breathing" under anæsthetics, and especially under chloroform, what is usually meant is the failure due to an overdose. The nervous system becoming paralysed, the medullary centres cease to act,

and the respiratory movements, becoming feebler and feebler, at length stop altogether. The ashy-grey pallor and imperceptible pulse, the entire cessation of breathing, the complete relaxation of the tissues, extending sometimes even to the sphincters, the widely dilated pupils, the general aspect of the patient, not unlike the *facies hippocratica* of actual death, are all very characteristic, and in fact may almost be said to be pathognomonic of chloroform poisoning; sometimes, the respiratory failure is almost lightning-like in rapidity, but more often it is gradual and insidious in onset.

As is well known, the clinical signs and symptoms of respiratory paralysis closely resemble, and are frequently associated and coincident with those due to syncope, and, on the other hand, obstruction to the breathing sooner or later leads to cardiac failure. In practice, it is often impossible to decide whether the respiratory or the cardio-vascular system was first affected, but it is of the utmost importance that the administrator should be able to appreciate the fact, that certain signs and symptoms are indicative of approaching danger from their very commencement. Such early recognition of symptoms is only possible when the administrator is unceasingly vigilant, and single-minded in his attention to his duties, and the obvious advantage is, that when thus recognized the mere withdrawal of the anæsthetic often suffices to correct the error, without subjecting the patient to any additional risk.

It is to the respiratory and the circulatory systems, and especially the former, that the greatest attention should be devoted, and the slightest alteration in either one or the other should be carefully noted and watched. If this be done, it will soon be seen that **signs of danger** may very readily be grouped under three heads, namely,

(1) Symptoms in which cardiac failure or syncope is the prominent feature. (Pallor, pulse gradually becoming imperceptible; pupil slowly dilating; respirations unaltered at first, but gradually failing, though seldom abolished completely.) Generally to be looked for in the earlier stages of anæsthesia; often the precursor of sickness. As a rule, easily recoverable.

(2) Symptoms in which the respiratory failure is the most prominent feature. (Respirations early affected, feeble, and shallow; pallor, often of the ashy-grey type; pulse fairly good at first, but slowly failing; pupils quickly dilating.) A condition of the middle and late stages, and tending to merge into

(3) Simultaneous or almost simultaneous, sudden, and complete cessation of both circulation and respiration, with facies hippocratica, suddenly and widely dilated pupils. May occur early (syncope) or late (toxic overdose). A very serious condition; when fully developed in the earlier stages of anæsthesia, it is doubtful if recovery is possible.

Treatment.—Reference has already been made (see p. 95) to the treatment to be adopted when, in ether anæsthesia, the muco-salivary secretion becomes excessive, and to the treatment of spasm of the glottis. The treatment of other forms of gross asphyxia is so perfectly obvious, that it may be dismissed in a very few words. If, with a patient sitting up, as for nitrous oxide anæsthesia, blood or a foreign body, such as a tooth, slips back into the larynx, the body of the patient should be bent sharply forward so as to bring the head over the knees; coughing should be encouraged by smartly patting the back, and by passing the finger into the throat to irritate the vocal cords. This latter manœuvre may reveal the presence of the foreign body itself, and an attempt may be made to remove it by means of the laryngeal forceps (Fig. 34); if this attempt do

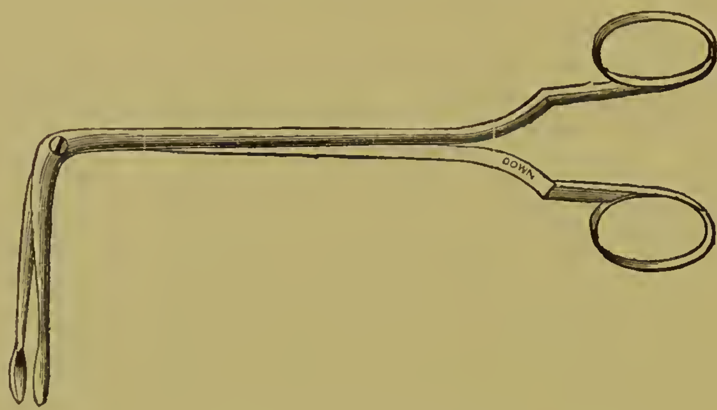

FIG. 34.—LARYNGEAL FORCEPS.

not succeed, the advisability of performing tracheotomy, or even better, laryngotomy, must be considered. Of course, in many cases, this operation would be performed by the operating surgeon, but the administrator should always be provided with suitable instruments, for occasion may arise, *e.g.* in dental work, in which they may be urgently called for and when the anæsthetist may himself have to operate. In any event, the responsibility rests with the anæsthetist.

In respect to the other symptoms mentioned on p. 111, it must be borne in mind that, although in some instances their development is almost unavoidable, yet in many if not in the majority of cases in which they are very pronounced, they can be traced to some error of omission or commission on the part of the anæsthetist. It may not, therefore, be out of place to recapitulate what may be termed the **prophylactic treatment** in respect to these symptoms, viz.,

(*a*) Take care to remove beforehand anything that may obstruct the breathing, or that may fall into the throat when the parts are relaxed (see p. 84).

(*b*) Excepting in the case of nitrous oxide, always induce anæsthesia gradually; this does not of necessity mean slowly, but rather the graduation

of strength of the vapour, not increasing the strength beyond that which can be readily borne.

(*c*) The administrator should devote the whole of his attention to the administration. He should not be called upon to hold instruments, or otherwise assist the surgeon, or even interest himself about the operation.

(*d*) As soon as sufficiently relaxed, the head must be turned to one side, so as to permit the mucus to flow out of the mouth and prevent the tongue falling backwards.

(*e*) The respiration must be watched with particular care, the hand being occasionally held in front of the nose and mouth to test the force of the breathing. The movements of the chest and abdomen are not to be relied upon, as they may be altogether out of proportion to the amount of air actually entering the lungs. Nor is the sound of the breathing to be depended upon; it may be largely due to mucus, or to buccal or palatine stertor. In my opinion, too, mechanical indicators in the shape of feathers, etc., are apt to be fallacious. They induce a false sense of security, as they do not distinguish between a very light and a moderately forcible expiration. At the same time the circulation, as indicated by the colour of the face and ears, should be watched, and the pupil observed.

(*f*) If in doubt as to the exact significance of any particular or peculiar symptom or change, it is safer to allow the patient to come round rather than press the anæsthetic.

Active Treatment.—If, however, any of the conditions indicated on p. 111 have developed, the following routine treatment should be adopted. It is of importance that the exact order of procedure be observed; that each step be carried out deliberately and completely, without flurry; that a wait of at least a few seconds be made between each movement, to be sure of its effect, and, in extreme cases, that treatment be persevered in for some time, even although apparently hopeless.

(1) Keep the head turned to one side, but do not otherwise alter the position of the patient. Withdraw the anæsthetic. Extend the head upon the trunk by pressing backwards upon the forehead; release the base of the tongue by forcible pressure upon the lower jaw at the angles, so as to protrude the lower incisor teeth beyond the upper, or by pulling forward the chin so as to **raise the hyoid bone and larynx.** In the very earliest stages of respiratory embarrassment, often nothing more than this is required. If the breathing be not restored by these means the next step is,

(2) Open the mouth, by means of the gag (Fig. 35), if necessary, seize the tip of the tongue in the forceps (Fig. 36), and **pull the tongue forcibly forwards.** This does not move forward the base of the tongue to any appreciable extent, but probably it mainly acts reflexly, and causes the retraction of the soft tissues in front of the glottis, and is, therefore, of particular service in the condition described by Lord Lister (see p. 103).

(3) Should the above manœuvres have no effect, the next proceeding is to explore and **clear out the air-way.** The finger is passed to the back

of the throat, and used as a hook to draw forward the epiglottis and base of the tongue, and this has often a very marked effect, and should on no account be neglected. At the same time, anything in the shape of a foreign body can be felt for, and, if found, attempts may be made to remove it with the finger, or by means of the laryngeal forceps (Fig. 34). The throat must be sponged to get rid of the mucus and blood, and, if this be excessive, the patient may very gently be turned on one side.

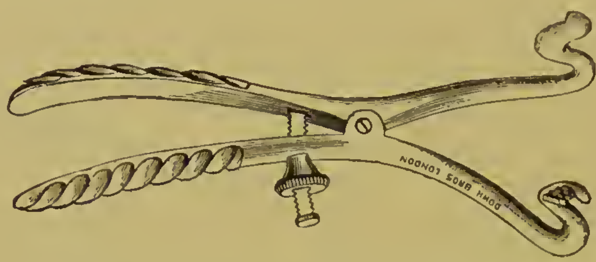

Fig. 35.—Ferguson's Mouth Gag. The toothplates must be protected with pieces of rubber tubing.

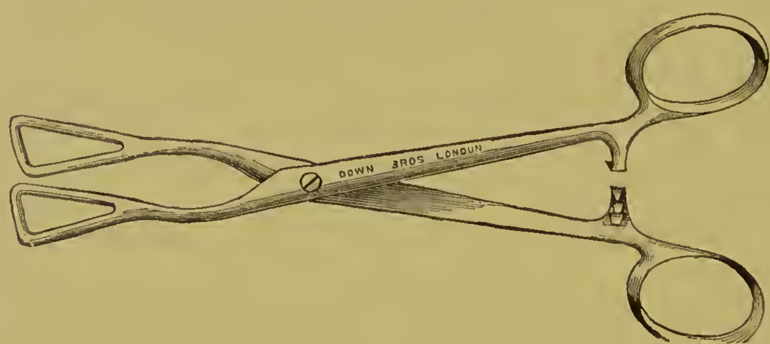

Fig. 36.—Tongue Forceps.

If a foreign body or definite obstruction can be felt, but cannot be removed with the finger or by means of the forceps, and if the asphyxia is becoming more intense, the question of tracheotomy may now arise, but mere feeble breathing, without definite signs of obstruction, is no indication for opening the trachea.

It is absolutely essential to commence with the above three proceedings as preliminary to anything else that may be done; it is useless to attempt to force air into the chest, by artificial respiration or other means, unless we first assure ourselves that the air-passages are clear. Violent movement of the patient at this early stage may have no other result than that of shaking the last flicker of life out of his body; do not, therefore, be over hasty. If, after waiting for ten or fifteen seconds, we get no response to our efforts, the next steps are,

(4) Make two or three **momentary pressures upon the sternum**; it may be that it is merely the rhythm of respiration which is in abeyance.

(5) **Invert the patient.**—Children may be held up by the heels; with adults, an assistant standing on the table may hold up the legs, and the body of the patient may be pulled upwards, so that the head hangs over

the end of the bed. One theory explaining the action of this proceeding is, that it empties the blood from the abdominal viscera towards the heart and brain. The effect, therefore, is one of mechanical stimulus, and, if this be so, one can understand the advice which is given not to prolong the position for more than a few minutes at a time.

(6) In adults, even while inversion is being tried, **artificial respiration** may be started, commencing slowly and gradually. The well-known Sylvester's method is the one usually adopted. Standing at the patient's head, a firm grasp is taken just below the elbows, and the arms brought outwards and upwards with a rotatory movement, some force being used to cause the forearms to cross above the head; expiration is brought about by reversing the movement, pressing the arms firmly against the chest walls so that the forearms cross over the front of the chest. In Howard's method, which is a most valuable adjunct to the above, the surgeon kneels astride of the patient, places his outspread palms over the margins of the ribs, pushes up the abdominal viscera against the diaphragm, and then allows them to fall away, and so alternately diminishes and increases the capacity of the thorax. In infants, too, it is useful to remember that pressure on the abdomen upwards towards the diaphragm, or upon the costo-diaphragmatic margin is often more effectual than anything else. When possible, these two methods should be carried out simultaneously, but in any event, the movements should not be made roughly or too rapidly; about sixteen or seventeen to the minute is ample.

It has been urged against these two plans of artificial respiration, that there is a danger of pumping up the contents of the stomach into the pharynx, and so practically drowning the patient, and the Marshall Hall method of turning the patient alternately upon his face and side has been suggested as an alternative. But the objection can hardly apply unless the movements have been made altogether too violently and too quickly, and mention is only made of it here in order to emphasize these points, and to put the administrator on his guard.

In the majority of cases, if the breathing has shown no signs of recommencement after artificial respiration has been continued for five or ten minutes, the prognosis is exceedingly grave; but it is not altogether hopeless, so that, while still persevering with the artificial respirations, some of the following plans should be adopted by the assistants. It must be quite understood, however, that these plans are to be carried out concurrently with the artificial respiration, and on no account is the latter to be superseded by them.

(7) **Cold affusions** in the shape of douches or flipping the chest with wet towels. Alternate very hot and cold sponges to the perineum.

(8) **Inhalation of nitrite of amyl** to alter the distribution of the intravascular tension. Strong ammonia held to the nose.

(9) **Electricity.**—Either the interrupted (Faradic) or the continuous current may be used. One pole is applied to some neutral point, *e.g.* the

nape of the neck, and the other pole is pressed over the cardiac area, along the costo-diaphragmatic margin, or along the course of the phrenic and pneumogastric nerves in the neck, the current being alternately made and broken.

(10) **Hypodermic injections of ether** or brandy (mxxx.) are usually given, but the proceeding is a little illogical. The patient is already suffering from a form of alcoholic poisoning, and, further, the circulation is too depressed to hope for absorption. For this latter reason, too, the hypodermic injection of drugs, such as digitaline, is hopeless at this stage.

(11) The **intra-venous injection of normal salt solution**, or rectal injections of the same, appear to be more rational. By altering the blood pressure they might possibly stimulate the circulation.

(12) As almost a last resource, **acu-puncture or galvano-puncture of the heart** itself has been recommended. It has even been suggested that by making a small incision along the margins of the left ribs, the fingers of the hand can be passed in, and direct pressure applied to the heart. I have no personal experience of these measures, but it appears to me that acu-puncture and galvano-puncture not only waste valuable time, but are more likely to do harm than good. The plan of directly pressing on the heart seems to be better justified, theoretically, but I am not aware that it has ever been put to practical proof.

Supposing that no response has been obtained to these efforts, the artificial respiration should be persevered in for at least half-an-hour, and of course, if the slightest attempt at natural breathing be made, a longer time should be given to the work. Even after a fairly regular, though feeble respiratory rhythm has been re-established, the greatest care should be taken in moving the patient, as relapses are very apt to occur; he should not, therefore, be left for some hours, and should be kept very warm.

After-Treatment.

In conclusion, a few words may be said as to the after-treatment of patients recovering from an anæsthetic, as this is a point upon which the anæsthetist is often consulted. Practically, no after-treatment is required for nitrous oxide; the following remarks are intended only for the major anæsthetics.

In dressing a case after operation, care should be exercised that the bandages, etc., do not impede the breathing. This is particularly necessary in operations about the head and neck, and it comes within the province of the administrator to see that no trouble arises from this cause. In these cases the bandages should be applied fairly firm, while the neck is fully extended; the pressure will not then be too great when the neck is restored to position.

In ordinary cases, the patient may be put back to a warm bed before he completely recovers consciousness. In making the transfer, however,

care should be taken not to jolt him, and especially not to elevate the head and chest; in going upstairs, therefore, he should be carried on a stretcher, feet first, with his head down. The room should be of a temperature of about 65°–70° F., and the bed carefully screened from draughts. If ether has been employed, and perhaps in all cases, it is better, if the surgeon will permit, that the patient be turned upon the right side; this facilitates the escape of mucus, and I think lessens the sickness. The nurse should be warned that if sickness occur the patient is not to sit up, but to be turned on his side, and, if need be, the jaw must be pushed forward to facilitate the escape of the vomited matter.

The anæsthetist should assure himself that his patient is on the high road to recovery before he leaves the patient's side, but on the other hand, natural sleep is to be encouraged; if, when taken at intervals of two or three minutes, the pulse and respiration are found to be good and improving, it may fairly be assumed that, as far as the anæsthetic is concerned, the patient is safe. In any event, whether the case is a severe one or not, the patient should always have a responsible attendant at his bedside for an hour or two after the operation has been completed.

Sickness.—As soon as he is sufficiently conscious to be able to do so, the patient should be encouraged to frequently rinse out his mouth and throat with warm water. If it occurs early, in the semi-unconscious condition, retching and vomiting are less distressing to the patient than at first sight appears; when he becomes fully conscious he seldom retains any recollection of his previous misery. Nevertheless, attempts should be made to ameliorate his condition. Sips of water as hot as can be borne, or even full draughts of half a tumblerful, are often successful; strong, hot, black coffee is good in some cases; 15 to 20 grains of bicarbonate of soda in a tumblerful of hot water is good in others; ice to suck is the routine treatment, and is very comforting to the patient; strychnine in 5m. doses of the liquor by the mouth or hypodermically, has been recommended, and in the more troublesome cases morphine may be called for, but in the majority of instances time alone is all that can be depended upon.

In cases involving severe "**surgical shock**," additional care is called for. In such cases, the amount of the anæsthetic used in the latter stages may, with advantage, be very much diminished, and strychnine hypodermically may be given freely (see p. 84). It is in these cases, too, that the hypodermic injection of brandy or ether may be of some possible value, but a nutrient enema of hot fluids is probably better (see p. 83). Such patients should not be put back to bed too soon, but be kept on the operating table, which should be raised some four or five inches from the ground at one end so as to raise the patient's legs. Hot water bottles should be placed all round the body and extremities, taking particular care whenever hot bottles are used, that they are thickly covered in flannel; patients, when anæsthetized, are very apt to be blistered unless the bottles are covered.

If the shock be the result of loss of blood, it may be advisable to give an intra-venous injection of normal salt solution, or rectal injections of salt and water (see Chap. VI.), but probably the hot nutrient enemata recommended above is more efficacious.

Diet.—No food should be given by the mouth for at least three or four hours after an anæsthetic has been administered, (in the case of nitrous oxide, however, an hour's abstinence will suffice), and a further wait of two or three hours should be made unless the patient express a desire for food, or if the sickness be very persistent. In cases of collapse, marked emaciation and feebleness, etc., nutrient enemata should be given every two or three hours, commencing immediately before the operation, rather than run any risk of irritating the stomach. The first food by the mouth should take the form of broth, beef-tea, or soup, rather than milk, which is apt to form a hard indigestible curd which may irritate the stomach in its catarrhal condition. When the first food has been retained, the patient may return by degrees to the ordinary diet, as far at any rate as the anæsthetic is concerned.

Delirium and excitement, when they occur, must be gently restrained, but the patient must not be tied down. In the case of lunatics, the feeble-minded, and even those with a previous history of mental disturbance, the friends should be warned that a recrudescence of the mental trouble occasionally occurs after the administration of any anæsthetic.

LOCAL ANÆSTHESIA.

Preliminary Observations.

Whether pain be the result of disease or be caused by surgical interference, the first and most natural impulse is to seek relief in local applications; we find, therefore, that such applications have been in vogue from the earliest times. The use of inhalations of the vapours of ether and chloroform, quickly supplanted the less certain and somewhat empirical local methods formerly employed, and it is only during the last ten or fifteen years that the production of local anæsthesia has been systematically studied; and it is even more recently that any attempts have been made to define its advantages and limitations. It is to Continental and American surgeons that we are chiefly indebted for our knowledge of the subject; in this country, the plans advocated have met with but a limited amount of support.

Advantages.—It is claimed for local anæsthetics that no previous preparation of the patient is required; that they are on the whole more portable and more readily available than most general anæsthetics; that they are easy of application; that it is sometimes of advantage that the patient should be able to assist the surgeon in his manipulations, *e.g.* by

forcing down a hernia; that they can often be used when a general anæsthetic would be inadvisable, *e.g.* in cases of collapse, and in the very emaciated and feeble; that, on the whole, some of the methods, *e.g.* freezing, are safer, and are less likely to be followed by disagreeable after-effects. Against this list of advantages, must be balanced the rather more weighty **objections** that they are uncertain in action, and cannot always be relied upon to produce the desired effect, so that it is usually necessary to hold a general anæsthetic in reserve, to be used if required; the element of shock is seldom abolished or even diminished; the tissues are unrelaxed; the appearance of the surrounding parts is so altered by the œdema, etc., that dissection becomes almost impossible, and it is open to question whether the healing of the wound be not retarded; the fear of the operation, and the very disturbing element of the sight of instruments, blood, etc., has always to be reckoned with, even in the apparently robust and firm-minded.

Cases suitable.—A careful study of the lists which have been published, of operations which can be and have been performed by the aid of local anæsthetics, and having regard to the attendant circumstances of the cases recorded, leads one to the conclusion that, as far as our present knowledge goes, the only occasions on which local can claim any real advantage over general anæsthesia are as follows, viz.,

(1) In very brief cases where no dissection is required, *e.g.* simple puncture or incision of small abscesses, and when nitrous oxide is not available or is objected to.

(2) In the aged, whose whole nervous system and tissues generally are often less sensitive than in younger people.

(3) In those who are much collapsed, or feeble and emaciated, and in whom, therefore, there is reason to fear the effect of a general anæsthetic in depressing the already reduced vitality.

(4) In ophthalmic surgery, and in some operations involving the superficial mucous membranes, *e.g.* nasal polypi.

Although special preparation of the patient is not so imperatively called for as with general anæsthesia, it is, nevertheless, of advantage, that the general condition should be improved by careful regulation of the diet, etc., for a few days beforehand. Purging or starving are not, of course, at all necessary; in fact, it is better that the patient should have a cup of hot broth or beef-tea immediately before the operation; this may counteract any tendency to syncope, and for the same reason a little stimulant is not objectionable. Whenever possible, the patient should be recumbent.

Methods.—The local methods most in use at the present time may be considered under the following heads, viz.: (1) Freezing; (2) Drugs; (3) Infiltration.

Freezing.

The anæsthetic properties of intense cold have long been made use of in practical surgery. In operative work, the cases most suitable for

freezing are those which do not involve any large area of surface, but which only require a short, simple incision or puncture, *e.g.* opening a superficial abscess. The method is open to the special objections that the tissues are apt to become so hard, that it is sometimes difficult to cut through them, so no dissecting operation can be carried out; and that the process of thawing is often accompanied by much pain, the healing is retarded, and the tissues are liable to slough.

A simple plan is to employ a mixture of two parts of pounded **ice** to one of **salt**. This is placed in an india-rubber bag, and laid upon the part to be operated upon until the latter assumes a dead-white colour, and is frozen hard. This plan is hardly to be recommended in any case; too large an area is frozen, and there is a great tendency for the parts to slough.

The late Sir Benjamin Ward Richardson was a great advocate for freezing anæsthesia, and introduced the **ether spray** (Fig. 37). The ether used for this purpose is the methylated ether, and is often known as

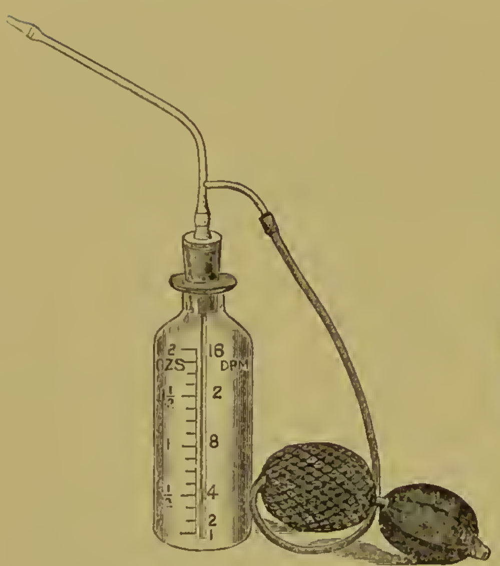

FIG. 37.—ETHER SPRAY.

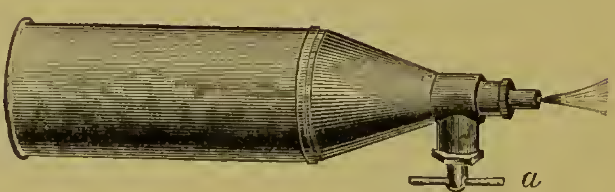

FIG. 38.—METAL BOTTLE CONTAINING ANÆSTILE. The tap *a* being unscrewed, the heat of the hand forces a minute stream of liquid out of the orifice.

"anæsthetic ether"; it should have a *spec. grav.* of ·717 or under. The nozzle of the spray is held a few inches away from the part to be frozen, so that the liquid falls in a fine shower upon the surface; in about two minutes the skin becomes hard and white, and the incision may then be made.

A very convenient adaptation of this principle of freezing by evaporation is seen in the use of tubes containing **ethyl chloride, anæstile,** and other fluids of low boiling point (Fig. 38). In these tubes, the heat of the hand suffices to drive a stream of the liquid through a minute hole in the nozzle, and at a distance of a few inches the jet is broken up into a fine spray, and the part upon which this spray falls is quickly frozen. These substances appear to be rather more rapid in action than pure ether, to

produce a sufficient, but not too great a fall in temperature, and, therefore, the hardness of the skin, and the after-smarting are less obvious objections than when simple freezing or the ether spray are employed. In using these tubes, care must be taken that the nozzle is held far enough off the part to enable the stream of fluid to fall in a fine shower upon the surface, otherwise, free evaporation does not take place, and the freezing is much delayed.

Drugs.

Many drugs, partly by their direct action upon the nerve endings, partly by the pressure of the fluid injected, partly by interfering with the blood supply of the part, have an anæsthetic action upon the tissues in the immediate vicinity of their point of application. For instance, an incision made into a tissue upon which pure carbolic acid, or even a solution of 1-20, has been painted, will hardly be felt, but this plan is not to be recommended, The drug generally employed nowadays is **cocaine**. This is the crystalline, active principle of the leaves of the coca plant (*erythroxylon coca*), and its chemical constitution is represented by the formula $C_{17}H_{21}NO_4$. The alkaloid itself is nearly insoluble in water, but the hydrochlorate is freely soluble, and is the form in which the substance is generally used. Solutions of this salt are particularly prone to decomposition, and numerous forms of infective bacteria frequently appear. To a considerable extent, this is prevented if 5 per cent. of salicylic acid be added to the solution.

When first introduced into surgical practice, the use of 5 per cent. and 10 per cent. solutions was advised, and these are about the strengths still usually employed in this country. On the Continent and in America, however, where, as already mentioned, the subject of local anæsthesia has received much attention, it has lately been proposed to use rather larger quantities of much weaker strength (1 or 2 per cent.), with a view to avoiding the untoward symptoms which frequently occur when the more potent solutions are employed. In any event, not more than from $\frac{1}{2}$ to $\frac{3}{4}$ gr. of the drug itself should be injected hypodermically at a single sitting.

In using cocaine, it is particularly advisable that, whenever possible, the patient should be recumbent, and, as a useful precaution, a cup of broth or beef-tea, or an alcoholic stimulant may be given beforehand.

The following are the principal plans adopted, viz.,

(1) **Instillation.**—In ophthalmic surgery a few drops of the solution are placed in the eye, and the instillation is repeated at intervals of three or four minutes, until a sufficient degree of anæsthesia has been obtained; this is usually after the lapse of from five to ten minutes.

(2) **Spray.**—This is useful in operations about the nose and larynx. A convenient form of spray-producer is shown in Fig. 39. A

few drops are sprayed at intervals over the surface to be operated upon, as with instillations.

Fig. 39.—Cocaine Spray.

(3) **Painted** on the surface, *e.g.* mucous membranes, etc. Or a pledget of cotton wool soaked in the solution may be allowed to remain for a few minutes in contact with the area of operation. This latter plan is useful in operations about the anterior nares and aural meatus, but mere painting on the unbroken skin is of but little service.

(4) **Hypodermically.**—The weaker of the solutions are used for this purpose, and from three to five minims are injected in the direction of the proposed incision, and the injection is repeated once or twice at different angles, so as to infiltrate the surrounding tissues.

Dangers.—Many people are particularly susceptible to the action of cocaine; even a few minims sprayed upon the throat may then give rise to a train of really alarming symptoms, such as vertigo, dryness of the mouth, dilated pupils, cold extremities, palpitation, slow pulse of high tension, restlessness, delirium, etc. Should such symptoms develop, the patient must immediately be placed recumbent, hot bottles applied to the extremities, stimulants given, and other precautions taken to avoid collapse. It is said by some that these poisonous effects are to some extent prevented, if antipyrine be added to the solution. A very good formula is the following, viz.,

Cocaine, - - - - - - - -	9 grains.
Antipyrine, - - - - - - - -	75 grains.
Sterilized water, - - - - - -	½ ounce.

An artificially prepared alkaloid, closely allied to cocaine, has recently been introduced. It has been called **eucaine**, and appears likely to supplant cocaine for many of the purposes for which the latter is used. Solutions of the hydrochlorate of eucaine are less liable to decomposition than salts of cocaine, and, while almost equally efficacious, they seem to be far less likely to give rise to toxic symptoms. For ophthalmic surgery, however, eucaine does not appear to be so satisfactory, as it sometimes gives rise to conjunctival irritation.

Eucaine should be used in the same way, and in solutions of the same strength as cocaine, but as its toxic effects are only about two-thirds that of the latter drug, it may be administered in proportionately greater quantities.

Infiltration.

In 1891 Dr. C. L. Schleich of Berlin introduced quite a new departure in the matter of local anæsthetics. After a series of carefully planned and elaborate experiments, Dr. Schleich found that it was possible to produce a very complete degree of anæsthesia if the tissues were thoroughly infiltrated with a cold, neutral, salt solution, and that the effect was still further enhanced by the addition of minute quantities of certain drugs, such as morphine, cocaine, etc.

The formulæ for the solutions are :—To one litre or quart of sterilized water, to which has been added 20 drops of a 5 p.c. solution of carbolic acid, add :

No. 1, or strongest, solution.

Cocaine mur.,	2·0 gm.
Morph. sulph.,	0·25 gm.
Sod. chlor. (sterilized),	2·0 gm.

No. 2, or medium, solution.

To the litre as above,

Cocaine mur.,	1·0 gm.
Morph. sulph.,	0·25 gm.
Sod. chlor. (sterilized),	2·0 gm.

No. 3, or weakest, solution.

To the litre as above,

Cocaine mur.,	0·1 gm.
Morph. sulph.,	0·05 gm.
Soda chlor. (sterilized),	2·0 gm.

As much as 25 c.c. (6 dr.) of No. 1, 100 c.c. (3 oz.) of No. 2, and 500 c.c. (15 oz.) of No. 3, may be considered the maximum quantity of these fluids to be used for the average adult. No. 2 solution is used in 95 per cent. of the cases, while No. 1 is used in highly inflamed and tender parts, and No. 3 only in big operations when more than ℥3 is likely to be required.

In using these solutions, great stress is laid upon the technique of the proceeding. The essence of the process consists in raising a series of small wheals or bubbles under and around the area of operation; for each succeeding wheal, the point of the injecting syringe is inserted within the margin of that which immediately precedes it.[1]

FIG. 40.—ANÆSTHESIA BY INFILTRATION (Schleich). Needle introduced at some distance from the area to be operated upon, and made to pierce the true skin.

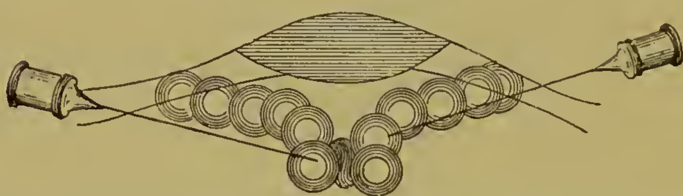

FIG. 41.—ANÆSTHESIA BY INFILTRATION (Schleich). Showing how the bubbles of liquid overlap, and are made to surround the affected area.

Excellent as this plan has no doubt proved in the hands of Dr. Schleich and his followers, it will be seen at once that it does not overcome many of the difficulties and objections made to local anæsthesia in general, under the head of "Preliminary Observations" at the beginning of this section. It is claimed for it that, as the process can be repeated without risk as often as may be required, it is quite possible to conduct an elaborate and lengthy operation by this method; but, on the other hand, it is obviously objectionable to break off an operation in the middle for the purpose of making a fresh series of injections, while the œdema produced renders any operation very difficult, and dissection almost impossible.

[1] For Figs. 40 and 41, illustrating the details of this method, we are indebted to the *Medical News of New York*.

CHAPTER VI.

WOUNDS.

MANAGEMENT OF OPERATIONS AND THE TREATMENT OF THEIR CHIEF IMMEDIATE RISKS: HÆMORRHAGE, SHOCK, AND SYNCOPE.

The subject of wounds, their varieties, complications and treatment, is one of the very highest importance. Wounds may be the result of accident or may be made intentionally by the surgeon, and between the two classes there are important differences. They may be divided into incised, contused, lacerated, gunshot, or poisoned wounds, and those caused by heat and cold. Certain points common to all wounds, such as the questions of pain, of shock, and of bleeding, and the risks of inflammation, also require to be studied. Lastly, various septic diseases which are apt to occur in connection with wounds, such as traumatic fever, traumatic delirium, septicæmia, hectic fever, pyæmia, tetanus, and erysipelas have to be taken into account. Before, however, proceeding to deal with them, it seems advisable to say a few words about the general management of operations.

Operations may be divided into two great classes, namely, those where the condition is urgent and the operation must be carried out without delay, and those where some time may be allowed to elapse after an operation has been decided upon. In the latter case various preliminary steps should be taken, some of which we shall briefly indicate.

PREPARATION OF PATIENT FOR OPERATION.

In the first place, certain points in the way of preparation of the patient should be attended to. Some of these are special to operations in certain regions, and will be mentioned in describing particular operations: such are the cleansing of the mouth and teeth in operations on the tongue, etc., washing out the stomach in gastrostomy and gastro-enterostomy, emptying the lower bowel in excision of the rectum, and so on. But, apart from these special matters, there are certain points common to many operations which will be considered here.

The mental attitude of the patient is a point of very considerable importance, especially as affecting the occurrence of shock during and after

the operation. When he has once decided to undergo an operation, the patient should be encouraged to look forward to a successful result; nothing is worse for him than to feel that he is going to succumb; shock certainly seems to intervene more quickly and more powerfully under such circumstances. Hence, although the patient and his friends should be made aware of the real danger and results of the proposed operation, as soon as its performance has been decided on the brightest side of the picture should be put in the foreground and any drawbacks made light of.

In regard to **feeding** before an operation, there is no object in interfering with the patient's usual diet on the preceding day, but it is well that the evening meal should be light and easily digestible. On account of the anæsthetic, food should not be given by the mouth later than three hours before the operation, and if this is to be performed in the early morning it is not worth while waking up the patient for a meal. If he be awake, it is as well to give a cup of strong hot beef-tea or Valentine's meat juice about six o'clock in the morning when the operation is to be performed about nine. When the operation is to be a severe one, it is also advisable to give a nutrient enema half an hour before operation; for methods of preparation, etc., see p. 83.

The bowels should in all cases be well cleared out before the operation, and the most satisfactory aperient is castor oil; about half an ounce should be administered over night, followed by a plain water or soap and water enema in the morning. The latter is made by rubbing up Castile soap in warm water till a pretty thick lather is formed, and about a pint is injected. Where the patient cannot take castor oil, or where it causes much griping, compound liquorice powder does very well, and a teaspoonful at night, followed by an enema in the morning, will generally suffice. The chief reason for clearing out the bowels, even though they may have been acting regularly beforehand, is that the patient is generally constipated after an operation and his digestion is more or less disordered; and, further, it is important to get rid of material which, by decomposing, may cause trouble, the septic products being absorbed and diminishing the patient's vitality. The evacuation of the bowels is also of importance in certain operations—for example, in piles—where steps are taken after the operation to delay their action for some time.

The most favourable time for an operation is the early morning, and that for two reasons. In the first place the patient, especially if he has passed a good night, has not so long to worry and excite himself about the operation as when a later hour is chosen; and, in the second place, he does not miss his food. It is very important, particularly in the case of nervous patients, to secure a good night's rest before the operation, and in most cases there is no objection to the administration of a narcotic, preferably a quarter of a grain of morphine, subcutaneously at bedtime. If there be any reason against the use of morphine, such as renal disease, the fear of headache, sickness, etc., the administration of

20 grains of sulphonal two hours before bedtime for two evenings preceding the operation may be substituted.

Selection of room and its preparation.—In private practice a room with a good light should be chosen, and a narrow table of sufficient height is essential to comfort. For this purpose, either a kitchen table or two small dressing tables placed end to end answer the purpose perfectly; if these be unobtainable, a couple of trestles with a board resting upon them can usually be fitted up. In town practice, it is sometimes advisable to carry one's own operating table, and light tables for this purpose can now be obtained of most instrument makers. Upon the table are placed a folded blanket and a pillow, and over the blanket, opposite the seat of operation, is laid a piece of mackintosh covered with a folded sheet, so as to keep the blanket and the patient's clothing dry. The mackintosh should not be spread over the whole table, as is customary among nurses, for, if this be done, the fluid soaks into the patient's clothes, and he is very soon lying in a pool of water. The mackintosh should be limited to the seat of operation, covered with a thickly folded sheet, and tucked into the clothing above and below that area.

DANGERS OF OPERATION, AND HOW GUARDED AGAINST.

The chief immediate risks of the operation are the dangers of the anæsthetic, loss of blood and shock; of somewhat less importance is the occurrence of syncope, while the risks of the introduction of sepsis must never be lost sight of. The first and last of these points are dealt with in their proper place; we may here, however, consider the others.

Hæmorrhage.

The question of bleeding is one of great importance. Bleeding may be arterial, venous, or capillary in nature. In arterial bleeding blood of a bright red colour spurts from the cut vessel synchronously with the systole of the heart, and flows continuously during the diastole. In venous bleeding there is a steady flow of dark blood, except in the case of the veins of the neck, where it flows in jets at each expiration with a steady flow between. Capillary bleeding is an oozing from the surface of the wound.

Mode of spontaneous arrest of bleeding.—Bleeding from any of these sources may cease spontaneously, or special means may be necessary to arrest it. The mode in which hæmorrhage ceases spontaneously differs according to the blood-vessels concerned in the bleeding. In the case of the arteries, when divided transversely the circular fibres of the muscular coat contract so that the orifice of the vessel is narrowed; at the same time the internal and middle coats curl up in the interior of the vessel, and the longitudinal fibres contract and shorten it, so that it

retracts within its sheath. As a result, there is clotting of the blood; as soon as the blood comes in contact with tissues which are injured, or which are not similar to the healthy lining membrane of the vessels, it undergoes coagulation. Consequently, as soon as the blood escapes from the vessel, clotting tends to take place, unless the escape of blood be so free that the clot is swept away by it. In the case of small vessels, clotting occurs where the blood comes in contact with the divided coats, more especially between the vessel and the sheath, and the clot formed there tends by its pressure to still further occlude the ends of the artery. This clot forms a mechanical obstacle to the escape of the blood (provided that the force of the blood stream be not sufficient to expel it), and it very soon extends upwards into the interior of the vessel, in most cases as far as the nearest collateral branch. The result is that a conical wedge of blood clot is formed inside the vessel which is very effectual in bringing about the cessation of bleeding. This, then, is the natural mode of arrest of hæmorrhage in divided arteries—the contraction and retraction of the coats, the curling up of the internal and middle coats, the clotting of the blood between the artery and its sheath, compression of the end of the vessel, the formation of a plug or clot in the open orifice, and the extension upwards of a conical wedge of blood clot towards the nearest collateral branch. As time goes on cells spread into this blood clot (in the first instance they are leucocytes, but later on plasma cells, cells derived from the endothelium, and from the connective tissues in the neighbourhood); these cells organize and form fibrous tissue, so that by and bye the divided end of the vessel becomes completely occluded by fibrous tissue and shrinks up. Ultimately a small fibrous cord is all that remains to represent the vessel from the seat of division to the nearest collateral branch. When an artery is only partially cut across, the contraction and retraction of its coats tend to enlarge the orifice, and so to increase bleeding rather than diminish it, and in these cases the natural hæmostatic process cannot occur until the vessel is completely divided.

Capillary bleeding ceases simply as the result of coagulation of blood in the capillaries. Venous bleeding, where the vein is only partially divided, ceases as the result of the formation of a small clot outside the vein, and the subsequent sealing of the part with lymph; where the division is complete, clothing occurs and the vein becomes closed by adhesion. It does not at all necessarily follow that a clot will form in the interior of a vein if it be only partially divided.

Means of controlling Hæmorrhage.

Where the artery is large the bleeding will not stop spontaneously, and some artificial means must be adopted to arrest it. Capillary bleeding is, on the other hand, only troublesome in cases of hæmophilia, where coagulation of the blood does not take place properly, and very

persistent oozing may occur. Venous bleeding usually ceases spontaneously, if a vein be not completely divided, except where severe coughing or crying gives rise to an obstruction to the flow of blood through the veins, and leads to jetting out of blood through the divided wall.

Tourniquet.—In dealing with hæmorrhage, it is necessary to consider not only its arrest, but also its prevention. Under certain circumstances it is advisable to arrest the circulation in the part upon which an operation is being performed. Formerly this was done by means of a tourniquet, a band tied tightly round the limb, furnished with a screw and a pad, which was placed over the artery, and screwed up till the circulation through the vessel was arrested.

Esmarch's bandage.—While the tourniquet arrested the circulation through the main vessel, it did not stop the collateral bleeding. At the present time an elastic band, with which the name of Esmarch is associated, is tied firmly round the limb at the upper part, and in this way the whole circulation, not merely in the main vessel, but in all the other vessels of the limb, is effectually controlled. In the case of weakly patients—for example, in cases of amputation—it is also of importance to preserve the blood which is already present in the limb; or to empty the limb of blood, for example, in suturing nerves where it is necessary to render the field of operation entirely bloodless. Esmarch's plan is to bandage the limb spirally from the extremity upwards, by means of a broad elastic bandage very firmly applied, so as to expel all the blood from the vessels; when the upper part of the limb is reached, an elastic tube or cord is applied transversely around it, and then the spiral elastic bandage is taken off. The objection to this method is, in the first place, that it is frequently undesirable, and, in the second place, it is unnecessary. It is a very undesirable method in cases of tumours or of suppuration, as in them the elastic bandage is very apt to squeeze pus or tumour substance into the tissues or the vessels during its application, and thus serious results may be caused.

Lister's method.—On the other hand, the plan introduced by Lord Lister, of elevating the limb for a few minutes before applying the elastic tourniquet, suffices to empty the limb of blood. If the limb be elevated the veins immediately collapse, and reflexly the main arteries contract, so that the limb becomes practically bloodless if the position be maintained for two or three minutes. When this has been done, and while the limb is still raised, an elastic bandage is applied in a circular manner around its upper part. In this way, a field practically as free from blood as by Esmarch's method is obtained without any risk of disseminating pus or tumour substance.

It is only in a few cases that this bloodless plan is of real advantage. It is of great value in operations such as suture of nerves or tendons, where the delicate dissections so often called for would be marred by the presence of blood in the wound. In amputations the arrest of the

hæmorrhage is very important, and the main vessel and its larger branches can be tied before the blood is allowed to flow through the vessels again. It is also useful in operations for necrosis, as it allows the surgeon to distinguish easily between the living and the dead part; but it is not so good in cases of tubercular joints, where the accurate recognition of the diseased tissues depends to a considerable extent on the vascularity of the part.

Objections to "bloodless methods."—There is one great general objection to the use of Esmarch's bandage, and the principle of bloodless operations generally. It is that, if the operation be a prolonged one, the after-bleeding is very severe, and the amount of blood lost by the patient is probably as great when the bandage is used as when it is not. Further than this, more time is spent over the operation, because an unduly large number of vessels have to be tied, and the wound cannot be sewn up until the oozing has stopped. When the bandage is removed after it has been on for some considerable time the vessels dilate, the limb is seen to flush and become much redder than its fellow, and there is in fact a certain amount of vaso-motor paralysis. As a consequence of this many of the vessels go on bleeding, and require ligature; had the bandage not been used the bleeding from these vessels would have stopped almost immediately.

Ligature.—Of the methods employed for the artificial arrest of hæmorrhage the best and most generally used is that of ligature. Where an artery is of such a size that the bleeding does not cease spontaneously soon after its division, it is well to apply a ligature to it. The effect of a ligature applied to an artery is to divide the internal and middle coats, which curl up in the interior of the vessel, and, further, to constrict the external coat firmly, so as to prevent the escape of blood from the vessel. Two varieties of material are used for ligatures, either absorbable materials, or those which are not absorbable or are absorbed only with very great difficulty; the best of the former materials is catgut. *Catgut*, unless specially prepared so as to harden it, is very quickly absorbed, and unprepared catgut in the tissues will not hold for more than a few hours. Lord Lister has devoted much time to the subject of the preparation of this material, and when prepared as he recommends, it will hold for some weeks before it begins to disappear. A reliable form is Lister's *chromicized catgut*, prepared as described in the *Lancet* for February 5th, 1881. The one that finds most favour at the present time is that prepared by means of sulphurous acid, and is known as Lister's sulpho-chromic catgut. Catgut in its raw state is full of bacteria, because putrefaction plays a part in its manufacture, the gut being allowed to decompose to a certain extent, in order to permit the mucous membrane to be easily stripped off the muscular coat. Hence, as it comes from the manufacturer, it contains living bacteria and their spores. In the process of preparation recommended by Lord Lister a considerable amount of disinfection takes place, so that the chromicized catgut immediately after it is prepared is prac-

tically aseptic. When kept in the dry state, however, it soon becomes covered with dust, and, unless properly disinfected before use, may give rise to sepsis. It should, therefore, never be used dry, or straight from the surgical instrument makers, but should be allowed to soak for about a week in a 1–20 watery solution of carbolic acid, and it will then be found quite satisfactory, and suppuration in connection with the ligatures will not occur. The catgut usually sold in bottles filled with carbolized oil should be avoided: it is unreliable for several reasons. Of course, catgut should never be disinfected by boiling, as the material swells up and becomes useless for purposes of ligature. The chromicized catgut should be used fine, except in the case of a large vessel such as the femoral or axillary artery, and the ends of the ligature should be cut quite short.

Among the non-absorbable materials *fine silk* is a good deal used for ligatures, and there is no real objection to it if it be quite aseptic. It is usually rendered aseptic by boiling, and is then afterwards kept in a 1–20 solution of carbolic acid. Before using, it is well to wash out the carbolic solution with one of sublimate (1–2000). These ligatures, like the catgut ones, should have their ends cut short. There is, however, no special advantage in silk, and it is a disadvantage to fill the wound with a large number of ligatures of a material which is not readily absorbed.

When an aseptic ligature is tied round a vessel, in the course of a few hours it becomes buried in lymph, and this lymph subsequently becomes penetrated with cells which organize into fibrous tissue, and which at the same time eat away the outer surface of the ligature, so that by and by these cells penetrate in between its strands. In this way the ligature is ultimately replaced by young fibrous tissue. In the case of silk a very much longer time is occupied by this process than in the case of catgut, and it may be months, or even a year or two, before the silk has disappeared, and sometimes small abscesses form and the silk is discharged.

Cautery.—In the case of vessels situated in parts where ligatures cannot be applied, the bleeding may sometimes be arrested by means of the cautery, the most convenient form being that known as Paquelin's cautery. It must not be used white hot, as in that case it will cut through the vessel, and bleeding will simply persist; it should be allowed to cool until it is hardly red, and if a hot point like this be held in contact with the vessel, it sears the tissues so that they stick together, and clotting occurs inside the artery.

Torsion.—Another way in which arterial bleeding may be arrested is by torsion. The object of torsion is to twist the end of the artery so that the middle and internal coats are ruptured and curl up, while the twisted external coat forms an obstacle to the escape of blood. In order to do this, the artery must be fixed above the point where rupture of the coats is required, as otherwise, in the case of a large artery at any rate, the only effect would be to twist the artery round and round in its sheath for a

great distance without attaining the required result. In the case of a large artery, therefore, the vessel is pulled out of its sheath and grasped transversely to its long axis with a pair of forceps above the point where the torsion is to be employed, and the cut end of the artery is then grasped by another pair of forceps, and twisted till the coats are felt to give way and till a sufficient twisted piece is left. Four complete revolutions generally suffice. In the case of small vessels, it usually suffices to get the artery as free from the surrounding tissues as possible, to grasp the tissues above the artery with the fingers of one hand, compress them firmly, and then twist up the part seized by the forceps with the other hand. Although torsion answers very well in many cases, we cannot recommend it as a substitute for ligature. It was introduced before the aseptic period, when ligatures had to separate, and when, therefore, there was a danger of secondary hæmorrhage; but nowadays, when ligatures are cut short and never separate from the divided ends of the artery, there is no risk of secondary hæmorrhage, and torsion, except for small vessels, has become more or less obsolete.

Pressure.—Pressure is also a very important method of arresting hæmorrhage, more especially of the venous or capillary variety; indeed, venous bleeding can be most readily arrested by it, and in many cases where it is undesirable to have ligatures on the surface of the wound, as for instance in cases of operations about the lips, the surgeon makes use partly of cold and partly of pressure to complete the arrest of the hæmorrhage. The pressure stops the flow of blood through the vessel while a clot is being formed. In speaking of pressure, we must mention the "**graduated compress.**" Where the bleeding point is deeply seated, and where it is not desired to open up the wound, pressure may be employed to arrest the hæmorrhage. If, however, the pressure be simply applied in the form of a pad over the surface of the wound, the bleeding may go on in the interior; a good example is bleeding from the cavity of a tooth after the latter has been extracted. Cases of this kind require the application of a graduated compress, that is to say, a tiny piece of gauze or lint is placed actually on the bleeding point, then pieces gradually increasing in size are added until a conical pad is formed, the outer part of which projects well above the surface. Then by means of a bandage, or in the case of a tooth by fixing the two jaws together, pressure is applied through the cone actually on to the bleeding point.

Temporary pressure by forceps.—A good deal can also be done in the way of arresting hæmorrhage from small vessels by pinching them tightly. The vessels are seized as free as possible from surrounding tissue with the point of a strong forceps, such as Spencer Wells', or, perhaps even better, those devised by Greig Smith (see Fig. 42), and are held in them for some little time. If, as the operation proceeds, the various bleeding points be compressed in this way and the forceps left on, it will be found that by the time the operation is completed and the forceps removed, only

a very small number of the vessels bleed and require ligature. Thus, by the use of these forceps, a great deal of time is saved in the course of a long operation. In the case of a breast amputation, probably not more than six or eight vessels will require ligature, whereas if all the bleeding points were ligatured, as was formerly done, the number of

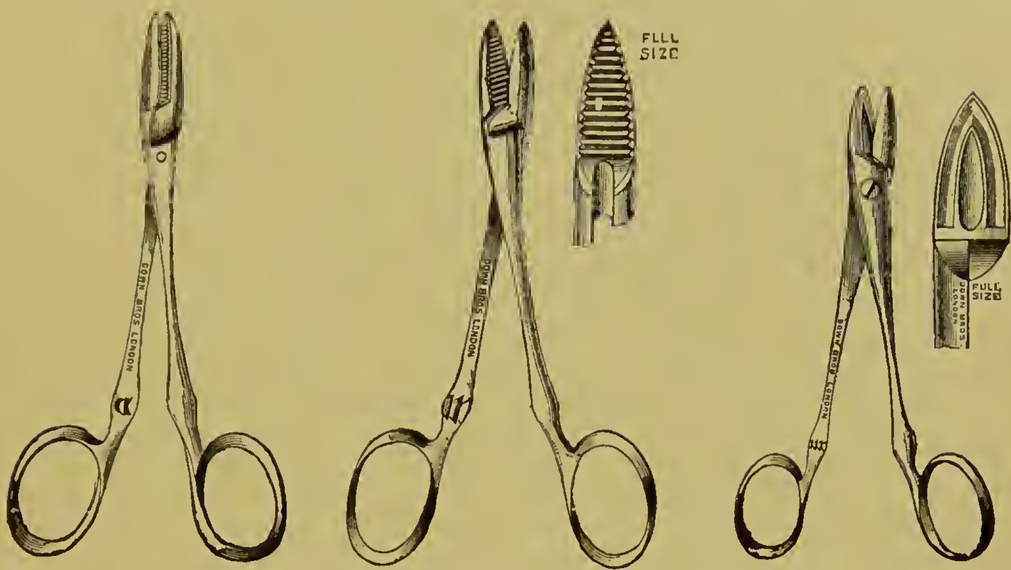

FIG. 42.—PRESSURE FORCEPS FOR ARREST OF HÆMORRHAGE. The above are the varieties in common use. A, *Spencer Wells'*; upon which most forceps for this purpose are modelled. B, *Lawson Tait's*; very similar to Spencer Wells', but so tapered at the points as to facilitate the application of a ligature. C, *Greig Smith's*; these forceps are designed to crush the walls of a vessel firmly together, and at the same time to cut through their inner and middle coats. The full-size illustration of the blade shows how this is done.

ligatures might amount to thirty or forty, or even more. The action of the forceps is to compress the end of the artery, and if they are kept on for a little time, when they are removed lymph is already effused, and sticks the compressed ends together, and a blood clot has formed in the interior.

Horsley's wax.—In the case of bleeding from bone, etc., Horsley has introduced an aseptic wax which can be applied over the bleeding point, so as to close the hole in the bone from which the blood comes. The composition of this wax is beeswax 7 parts, almond oil 1 part, and salicylic acid 1 part. When not in use, the wax is kept in a vessel of 1–20 carbolic solution. When it is required for use, a small piece is pinched off, softened by rolling between the fingers, which, of course, should be aseptic, and then pressed well into the part of the bone from which the blood is coming. The wax does not give rise to any trouble in the healing of the wound.

Cold.—There are various other ways in which bleeding may be arrested, and which are specially applicable to oozing from small vessels or capillaries which cannot be controlled by the means already mentioned. The

chief of these methods are those that tend to cause the contraction of the coats of the vessel, namely, the use of cold or heat. The application of cold to the skin over a bleeding part will lead, in the first place, to contraction of the cutaneous vessels, and reflexly to contraction of those of the deeper parts. For example, in operations about the mouth or lips, such as those for cleft palate or hare-lip, bleeding can be very quickly arrested by slapping the face with a cold wet towel, or dashing cold water upon it, or, if that fail, by the application of ice to the neighbourhood of the bleeding part.

The use of Leiter's tubes, which have already been mentioned in dealing with inflammation (see p. 9), is a very effectual method of checking bleeding. For example, in cases of hæmorrhage from the urethral mucous membrane occurring sometimes as the result of gonorrhœa, where no direct method of hæmostasis can be employed, a very excellent method is to coil Leiter's tubes around the penis, and pass a stream of ice-cold water through them. As the penis contracts with the cold, it is also well to pass a straight catheter a short distance up the urethra before fixing on the coil. The result of application of cold in this manner is that contraction of the vessels of the skin with subsequent contraction of the deeper vessels occurs, and if this be kept up for a short time coagulation will follow, and permanent occlusion of the bleeding vessels result. A piece of lint should be placed on the skin beneath the coil, and on account of the great cold which the use of these tubes may produce, the part should be looked at from time to time to see if it is becoming blue as the result of interference with the circulation through it, in which case the use of the coil must, temporarily at least, be suspended.

Heat.—Almost equally efficacious in arresting bleeding is heat, and douching the bleeding part with hot water has a powerful hæmostatic effect. The temperature of the water generally used is from 108° to 115° Fahr., and the affection in which it is chiefly employed is postpartum hæmorrhage, the uterus being freely flooded with water at this temperature.

Styptics.—Hæmorrhage may also be arrested by producing coagulation of the blood as it escapes from the vessel, and this is done by the use of styptics. In employing styptics it is useless to pour the solution into or to swab a bleeding wound with it. The bleeding must, in the first instance, be temporarily arrested, because, if the styptic is to act efficiently, the clot produced by it must form not on the surface of the wound, but actually in the orifice of the bleeding vessel. Hence the bleeding area is pinched up between the finger and thumb, and the bleeding thus temporarily arrested; it is then painted over with the styptic solution, and the pressure is maintained for a short time in order to keep the wound from bleeding, and to give the styptic time to act. The styptics usually employed are the liquor ferri perchlor, B.P., or the liquor ferri perchloridi fort. mixed with equal parts of glycerine, or tincture of matico. While perchloride of iron is the best styptic, it is objectionable in that it very often

causes a slough on the surface of the wound. In cases of operations upon the mouth or upon some part where sepsis subsequently occurs, this slough is a source of danger, as septic micro-organisms are likely to grow in it.

Fibrin-ferment.—In connection with styptics may be mentioned the fibrin-ferment introduced by Prof. A. E. Wright, of Netley, for the purpose of checking excessive oozing from large raw surfaces. A piece of sterilized lint, sponge, or muslin is saturated with the ferment solution and laid upon the oozing surface, so as to come thoroughly into contact with all the bleeding points. Its action is to induce rapid coagulation of the blood as it issues from the vessels, and, provided that these be small, the result is very good. In our hands it has seemed of value in cases such as excision of superior maxilla, operations about the throat, etc.; it must, however, be freshly prepared, and is difficult to obtain.

Drugs.—Lastly, we have the internal use of drugs which cause contraction of the vessels, of which the most notable is *ergot*. The fluid extract of ergot, given in doses of from 30 to 60 minims every hour, or even more frequently, for three or four doses, is a very valuable agent. Where a still more rapid effect is desired, a dose of one-fiftieth of a grain of *ergotinine* injected subcutaneously may be employed, and this may be repeated two or three times. A solution of *ergotine* may also be employed in doses of one to two grains injected at right angles to the surface of the skin well into the muscular tissues. Among other substances used for the same purpose may be mentioned *gallic* acid, which is given in doses of ten grains every two or three hours.

Another drug that has been employed for the purpose of increasing the coagulability of the blood is *chloride of calcium*, which may be given half an hour before operation in doses of 30 grains by the mouth, or better, since it is likely to induce vomiting, in doses of 1 drachm to the pint of water by the rectum. If it be employed, the cases for its use must be carefully selected. Its power of increasing the coagulability of the blood is undoubtedly very great, and therefore where there is much shock, and the circulation is much enfeebled, it may cause serious harm by bringing about thrombosis in the large veins, and its use is therefore not to be recommended where great shock is feared.

Symptoms of serious loss of blood.—The next point for consideration is the treatment of cases where so much blood has been lost, either from continuous oozing from the vessels, or from the sudden escape from some larger trunk, that the patient's life is endangered. Bleeding may also occur under the dressing, or into the abdomen in cases of abdominal operations, after the patient has been removed to bed, and it is necessary that the surgeon should be able to recognize the symptoms of loss of blood. These are pallor, a rapid, soft, and feeble pulse, gasping or sighing respiration from imperfect oxygenation of the blood, and a tendency to twitching of the muscles; the patient soon loses consciousness. The most typical

sign is the restlessness of the patient: he gasps for air, throws himself about, and uncovers his chest in his desire to get more air into his lungs.

Transfusion.—The occurrence of these symptoms should at once lead the surgeon to assume that bleeding is going on, and the dressing should therefore be removed immediately, and, if necessary, the wound opened up with the view of securing the bleeding point. In some cases the patient's condition may be so bad that it is not advisable to search for the bleeding point, lest he die during the attempt to find it, and here pressure must be resorted to for a time. In any case, if the loss of blood be serious, measures must be taken to restore the volume of fluid in the blood-vessels by means of transfusion. The fluid used for transfusion may either be blood, pure or mixed with phosphate of soda or defibrinated, or an indifferent fluid, such as the ordinary normal saline solution. As regards the use of blood, either pure or mixed with phosphate of soda, it has been found that the red blood corpuscles introduced soon die, and have comparatively little effect as carriers of oxygen, and there is great difficulty and risk in introducing pure blood, chiefly owing to the formation of coagula in the instruments, or the detachment of coagula from them giving rise to pulmonary embolism. Even defibrinated blood is not free from this last objection. On the other hand, indifferent fluids answer the purpose of giving the heart enough fluid to contract upon, and so enabling it to drive what blood corpuscles remain through the circulation, thus keeping the patient alive till fresh blood has been manufactured.

Hence, nowadays, the most common material for transfusion is the ordinary *salt solution* used in physiological work, that is to say, a ·75 per cent. solution of common salt. In practice, this is roughly about a teaspoonful of common salt to the pint of water. The water should be boiled and allowed to cool by standing under cover or in ice till it has reached 100° Fahr. In cases of emergency, however, it is not always easy to get boiled water, and if the water has to be boiled and cooled too much time is wasted, and therefore it is necessary to risk the introduction of organisms by mixing the water from the kitchen boiler with a sufficient amount of ice or cold water to reduce the temperature to the required degree. In introducing the saline solution, a vein is exposed (most conveniently the median basilic), a double ligature of catgut is passed around it, divided in the centre, and the two threads separated from one another. An oblique cut is then made through about half the calibre of the vessel between the two threads, and the nozzle of a suitable cannula is inserted into the opening and tied in by the upper of the two threads of the double ligature, the vein also being ligatured below by the lower thread, so that the blood does not escape from the distal end. There may be some difficulty in making the vein prominent in cases where the circulation is very feeble. If it cannot be seen by lightly constricting the upper arm, the best plan is to make a transverse cut across the direction of the vessel down to the deep fascia; the divided ends of the vein can then

easily be seen, the distal end ligatured, the proximal grasped with forceps, and the cannula introduced and tied in. Before the cannula is tied in a piece of india-rubber tubing is attached to it, and to this is fitted a glass funnel, or the barrel of a glass syringe from which the piston has been removed, washed in carbolic acid, and then filled completely with salt solution and the tube clamped so as to expel all the air. Care must be taken that no air gets in at any time. The funnel is held from two to three feet above the level of the patient, the clamp is opened, and the fluid is allowed to flow gradually into the vein (see Fig. 43), care

Fig. 43.—Transfusion. This shows the method of using the barrel of an ordinary glass syringe as a funnel. It is convenient in practice to have a clamp upon the india-rubber tube. There is a ligature shown in the illustration upon the distal side of the incision in the vein, the one on the proximal side serving to tie in the cannula.

being taken that the fluid in the funnel is replenished before it has quite run away, as otherwise air may get in when a fresh supply of the fluid is poured in. The rapidity of the flow can be easily controlled by raising the funnel more or less above the level of the heart; this can be better regulated by means of a funnel than if the saline solution be injected by means of a syringe. The amount introduced should be from one to three pints. The condition of the patient has to be carefully watched during its introduction. If it enter too rapidly, the fluid that is driven from the heart into the lungs may consist of pure salt solution, and consequently signs of imperfect aëration of the blood at once become evident; the respiration becomes embarrassed, and twitchings

and restless movements occur, and the patient may die at once. If any symptoms of this kind occur, the tube should at once be clamped so as to arrest the flow of the saline solution till the dangerous symptoms have passed off. Plenty of time should be taken in introducing the fluid, certainly from 20 minutes to half an hour, and it is well to stop every now and then to allow the blood in the body to be mixed thoroughly with the saline solution. In many cases, where the condition is less urgent, it is better to allow the fluid to be absorbed rather than to inject it directly into the circulation, and this may be done either by injecting the salt solution into the rectum, two or three pints at a time, or, if this be not retained, it may be injected into the peritoneal cavity, or even into the cellular tissue, especially that beneath the axillary fascia. In this way the absorption will be so regulated by the body that too rapid dilution of the blood will not take place. It may be necessary, in cases where a very large quantity of blood has been lost, to repeat the operation after the lapse of an hour or so. Usually, however, unless there be also great shock, one transfusion is sufficient to tide the patient over till a sufficient quantity of fresh corpuscles has been manufactured.

Transfusion of blood, either pure, diluted or defibrinated, has so little to recommend it that we need not take up space by describing the method.

Shock.

Shock may be defined as a state of great depression of the vital activity, into which a patient passes as the result of sudden, severe, or prolonged irritation of the peripheral nerves, especially of the sympathetics. The condition seems to be due to extreme exhaustion of the medulla and spinal cord, resulting in marked reduction in the activity of all the vital functions. Over-stimulation of sensory nerves leads to exhaustion and temporary suspension of function of the corresponding centres, and the longer the stimulation is continued and the greater its activity, the more profound and prolonged is the suspension of function, and the less is the probability of recovery. Much depends on the part of the body operated upon; for example, a great deal of time may be spent in repairing a badly united or un-united fracture of the extremities without producing anything like the amount of shock that a much shorter and gentler operation on the abdominal cavity will cause, especially if the peritoneum be inflamed. Loss of blood also increases the risk of shock, and it is thus more marked in operations where there is a great deal of hæmorrhage.

Symptoms.—If shock comes on during an operation, its presence is indicated by increasing pallor of the countenance and weakness of the pulse, which becomes rapid, dicrotic, and sometimes irregular. The pupils become dilated, the reflexes are slow, there is often sweating about the forehead, and the skin becomes cold. After the operation the pulse

remains bad and the patient cold, and, though he may to some extent recover consciousness, his senses are dull. When severe shock is established the probability of overcoming it is not great, and therefore it is highly important to take measures beforehand to avoid or diminish it as far as possible.

Treatment.—(*a*) **Prophylaxis.**—We have already referred to some of the points in the preparation of the patient which are of importance in connection with this question of shock, such as his frame of mind, a good night's rest previous to the operation, and the administration of food. Of especial importance is the *nutrient enema* of brandy and peptonized meat juice given half an hour before the operation (see p. 83).

An essential precautionary point is to take measures to *keep up the body temperature.* The operation should be performed in a warm room free from draughts, and a temperature of from 60° to 80° F. should be maintained. This, however, is not of itself sufficient in bad cases, and the best plan is to have the table on which the patient is lying kept at 100° to 105° F. by means of warm water. In some operating tables this is accomplished by having the top of the table composed of a series of tubes through which hot water circulates (see Fig. 44), but this necessitates a special table. An equally good plan is to have a large copper tray about 6 inches deep, and 5 feet in length, with a metal top, and tubes at the ends for the entrance and exit of hot water, which is kept circulating through it during the operation. Where this is not available, its place may be supplied by a water-bed or large water-pillow filled with water at a temperature of 110° F. The latter is especially good in cases of operation upon children, although from the movements it communicates to the patient it is inferior to the steadier hot-water table. The table is covered with one or two warm blankets, on which the patient lies, and the aseptic towels which surround the area of operation (see Chap. VIII.) are wrung out of hot lotion and changed at intervals. Where the arrangement above described is not available, the room should be kept as warm as one can work in. All lotions used during the operation should be at about a temperature of 100° F. In abdominal operations, if coils of intestine escape they should at once be replaced, and if it be necessary to keep them outside the body they should be covered with warm aseptic cloths or sponges frequently renewed. Several india-rubber hot water bottles should be placed about the patient, taking care of course to have them well covered with flannel so as not to burn him.

Rapidity of operation is also important in cases where shock is likely to occur. The steps of the operation should be carefully planned beforehand, and all necessary preparations made before the anæsthetic is administered, so that no time is lost afterwards. Where it is important to reduce the time that the patient is under the anæsthetic to a minimum, all preliminaries, such as shaving, purification of the skin, arrangement of aseptic towels, etc., should be carried out before the anæsthetic is com-

menced. Loss of blood should also be avoided as far as possible. The management of the anæsthetic has been specially referred to in the section dealing with anæsthetics (Chap. V.).

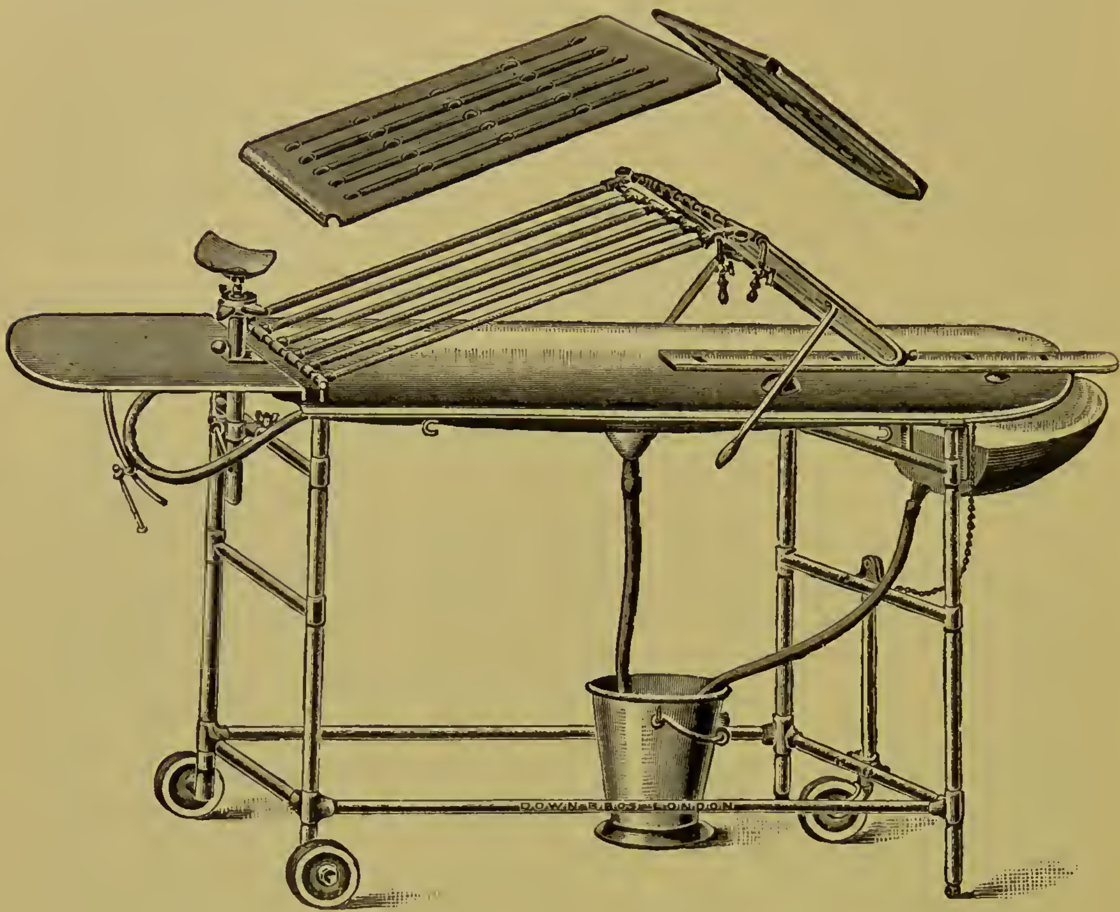

FIG. 44.—HOT-WATER OPERATING TABLE. The hot water circulates through the tubes, of which the entrance and exit taps are shown. The cover above serves to diffuse the heat uniformly. This form of table has the great advantage that the pelvis can be raised (*e.g.* when Trendelenburg's position is required) without interfering with the hot-water circulation.

Of the very greatest value in the prevention or diminution of shock is the administration of *strychnine* before the commencement of the operation. In the case of an adult, a thirtieth of a grain should be injected subcutaneously just before the operation, or while the patient is being placed under the anæsthetic; and during the course of the operation, if the pulse is beginning to fail, a second injection of a sixtieth of a grain may be administered. It is of the greatest importance to give the strychnine *before* the occurrence of shock, for when shock is once established remedies are of little avail, and recovery mainly depends on the patient's recuperative power. Death occurs partly from the severity of the shock (the nerve centres being unable to regain their power) and partly from its duration. Where the depression is long continued, and the circulation consequently extremely feeble, clots are apt to form in the pulmonary artery, and recovery is then out of the question.

(*b*) **When established.**—When shock is established vigorous measures must be adopted to combat it. In the first place, *warmth* is of the very highest importance; all wet cloths should be removed and the patient wrapped up in warm blankets, outside which hot bottles are placed; benefit will also be obtained by chafing the extremities and the abdomen. He should be put to bed as rapidly as possible and laid quite flat with only a thin bolster beneath the head, the foot of the bed being raised about 6 inches so as to favour the flow of blood to the brain, and he should be kept as still as possible so as not to exhaust the heart. Free stimulation is also important; perhaps the most rapid stimulant is *ether* injected subcutaneously in doses of from 20 to 30 minims. The point of the needle used for injecting the ether should be buried in the muscle, for if a large quantity be injected subcutaneously sloughing of the skin may occur. The ether may be repeated in 15 or 20 minutes if necessary, and *brandy* also may be injected in the same quantity still more frequently. *Tincture of musk*, in doses of from 20 minims to a drachm, is much employed on the Continent, but it must be freshly prepared, as otherwise it is very apt to contain septic organisms. Stimulants should also be administered by the rectum in the form of a hot *nutrient enema* containing half an ounce of brandy (see p. 83), and it may be advisable to give this during the course of the operation if signs of severe shock appear. Of drugs, the only ones that are of any avail are *strychnine* and *digitaline*, a thirtieth of a grain of strychnine (or a sixtieth if it has been already twice administered during the course of the operation as before directed), combined with a hundredth of a grain of digitaline. This may be repeated every hour if necessary for three or four doses.

Some authorities lay much stress upon the value of *transfusion*, which is performed as described on p. 136. The effect upon the pulse and the breathing should be carefully watched, and the injection continued until the pulse is felt to become full, regular, and approaching its normal rate. For this purpose at least two or three pints, or even more, of the saline solution will be required. Care should be taken to keep up the temperature of the fluid.

In cases where this transfusion is done chiefly for loss of blood, the *results* are doubtless often striking and most satisfactory, one injection being sufficient to tide the patient over his danger. Where, however, it is performed for pure shock the effect, although good, is often only temporary, and after the lapse of from a half to three hours the symptoms of shock begin to reassert themselves. Under these circumstances it may be necessary to repeat the injection, and cases have occurred where this had to be done a third or even a fourth time. The effect of this is, however, that the dilution of the blood may be so extreme as to produce imperfect aëration in the lungs, and sometimes severe dyspnœa may result. If this be the case the operation must be stopped, and reliance placed upon rectal injections and the administration of stimulants. The method of transfusion

as a treatment for profound shock, although it is worth a trial in severe cases, has not in our hands proved so satisfactory as the writings of some surgeons might have led us to expect.

Where the case is one of pure shock the further dilution of the blood can hardly be expected to aid the recovery of the nerve centres. A better method is to inject the saline solution into the rectum, and the advantage of this plan is that dilution of the blood does not occur so rapidly. Where a nutrient enema has been administered, half an hour or an hour must, however, be allowed to elapse before the saline solution is injected. In pure shock stimulants are of much importance, but where there is much hæmorrhage the saline solution is of more immediate value, and therefore an enema of one to two pints should be given at once, and repeated in an hour if necessary.

Influence of pain on shock.—A very difficult but at the same time a very important question is how far pain, when severe, keeps up the shock, and to what extent anodynes may be administered with the view of relieving it. There can hardly be any doubt that prolonged pain will cause exhaustion of the nervous system, and thus prolong or even set up shock, and it is therefore of importance to diminish it if possible. An injection of morphine before the patient comes round from the anæsthetic may diminish shock to some extent, but when once shock is established *morphine* alone is apt to cause a great deal of depression. The addition of *atropine* to some extent removes this objection, and therefore where there is much pain a subcutaneous injection of a quarter of a grain of morphine with $\frac{1}{120}$th of a grain of atropine is advisable.

Entry of air into veins.

In connection with bleeding from wounds, we may here consider the question of the entrance of air into veins, which often leads to very serious results. This accident is especially apt to happen in operations about the root of the neck on account of the proximity of the heart, and the fact that the veins pass through rigid openings in the deep fascia of the neck. In these operations, if a vein be opened, and not immediately occluded, air is apt to be sucked in through the proximal end of the vessel, during inspiration, and this will give rise to very serious symptoms, more especially to embarrassment of the pulmonary circulation. The right side of the heart becomes full of blood, which is frothy from admixture with air, and this material is not readily driven on into the pulmonary artery, and in consequence, in some cases immediate death is the result. In other cases where less air enters, death does not occur so suddenly. The patient cries and gasps, he struggles for breath, and becomes blue from non-oxygenation of his blood.

Where the amount of air sucked in is quite small the obstruction

may be overcome and the circulation re-established. In these cases, it is not uncommon for a small patch of pneumonia to form in the lungs where the bubbles of air and blood have collected. The accident is so sudden and dangerous, that the possibility of its occurrence should always be borne in mind by surgeons, especially in operating about the neck, and if veins must be divided, they should if possible be clamped before division; if, however, this be not done, the proximal end should be at once compressed by the finger, so as to prevent the accidental entrance of air, and a clamp put on as quickly as possible. The operation should not be proceeded with until the divided ends of the vein have been closed. The accident is more especially likely to happen where veins are only partially divided, and where the rent is made during the surgeon's manipulations, as for instance in pulling forward the thyroid gland during thyroidectomy.

Treatment.—If, during the course of an operation, symptoms arise which show that air has entered the veins, the wound should be flooded with lotion immediately the characteristic hissing or sucking noise is heard, with a view of preventing further entrance of air; and when this has been done, the next point is to make an effort to force the air out again from the vessels in the chest. This is best done by forcibly compressing the chest, while at the same time pressure on the vein is relaxed so as to allow the air and frothy blood to be poured out through its open end; on allowing the chest to expand the vein is again compressed, and so on. Another thing that may be done, is to aspirate the vein, a small tube such as a sterilized catheter being introduced into it, the end of the vein compressed tightly around it, and then an attempt made to suck the froth out. As a rule, however, where a large quantity of air has passed in, death is immediate, and it is quite impossible to save the patient.

Syncope.

Syncope is a not infrequent complication of operations. By the term is meant complete arrest of the heart's action, accompanied by loss of consciousness. This is in contrast to shock where the loss of consciousness is not complete, and where the pulse is always to be felt although it is often very feeble. Syncope or faintness may result from sudden loss of blood; from withdrawal of blood to another part, as in tapping the abdomen for ascites; or reflexly from sudden nervous shock, especially if the patient be not fully anæsthetised. Where the patient is not under an anæsthetic, syncope is usually preceded by vertigo, tinnitus, nausea, and imperfect sight, and these symptoms are followed by arrest of the heart's action, cessation of bleeding, marked pallor, dilated pupils, cold sweat over the forehead, cold extremities, respirations feeble or absent, and total loss of consciousness. The condition is due to a deficient supply of blood to the brain. Except in extreme cases, the arrest of the heart's action is

only momentary, and recovery is indicated by sighing and gasping respirations, reappearance of the pulse, and gradual return of consciousness.

In the **treatment** of syncope it must be borne in mind that the symptoms are essentially due to absence of blood from the brain, and steps should be taken to remedy this. Before syncope is completely established it is often sufficient to depress the patient's head well between his knees, so that it is at a considerably lower level than the heart, and under these circumstances the face will often flush and the feeling of faintness will pass off. Above all things, when syncope is established, the patient's head must be lowered; there is nothing more dangerous than to leave the patient sitting up, or with his head reclining upon a pillow; the heart may not act again in time to supply blood to the vital centres while recovery can take place. It is well also to elevate the legs so that any blood present in the lower extremities may run back into the larger vessels. The chest also must be free, and there must be nothing tight around the neck. Sudden shocks to the external surface will set up the heart's action again, the most favourite plan being to bare the chest and dash cold water over it, or slap it with wet towels. Cold water dashed over the head has similarly a good effect. The Faradic current may also be employed to the region of the phrenics so as to produce contraction of the diaphragm; this is best done by means of two small moistened electrodes about the size of a shilling, connected with an induction coil, which are pushed forwards beneath the posterior edge of the sterno-mastoids just above the clavicle on each side, and the current then made and broken from 15 to 30 times per minute. Each closure of the current causes an inspiration, followed by an expiratory effort. Direct stimulation to the region of the heart seems to do no good and may be actually harmful. The strength of the current should be from 5 to 15 milliampères.

There must be also plenty of fresh air; no crowd should be allowed to gather around the patient, and when he is able to swallow, a little brandy and water, or other stimulant, will aid the recovery. When syncope occurs during the course of an operation, the patient should be pulled up to the end of the table and his head allowed to hang over it, or the foot of the table may be tilted up. Artificial respiration must be employed, and slapping the chest with wet towels, and the application of the Faradic current to the region of the phrenic nerves, as just described.

AFTER-TREATMENT OF OPERATIONS.

When no collapse is present, the patient should be put to bed as quickly and gently as possible, and wrapped up in warm blankets. In most cases he should lie on his back, and where possible with only a thin bolster under the head. The room should be rapidly cleared and darkened, and the patient left perfectly quiet. If this be done the narcosis may pass

into ordinary sleep, which may last an hour or two, and in that case the patient may have no pain at all when he wakes up; at any rate the worst of the pain will have passed off, and the sickness will not be so great.

Feeding.—Neither food nor drink should be given for three or four hours after the operation; at most, a small quantity of very hot water or a teaspoonful of brandy and water if absolutely necessary. At the end of that time, if the patient desire food, some warm beef-tea may be given, and after about six hours, if there be no sickness, this may be alternated with milk and soda. It is well not to push the feeding for the first 24 hours, unless in the case of a very weakly patient, and even then two or three nutrient enemata or zyminized suppositories administered at intervals of four hours are better than feeding by the mouth. If feeding by the mouth be commenced too soon, or pushed too energetically, it is apt to bring on serious sickness. For the treatment of vomiting after an anæsthetic, see p. 117. If there be much pain, a quarter of a grain of *morphine* may be injected subcutaneously soon after the operation, but in most cases it is best to leave the patient alone.

The patient should always be seen on the evening of the operation in case he is in pain, for which morphine may be necessary; in case any bandage be too tight and require cutting; also in case there be retention of urine, which may occur not only after rectal and perineal operations, but sometimes in other cases. Other troubles of which the patient may complain are the occurrence of colicky pains and pain in the loins. Colicky pains are not uncommon, more especially after hernia operations, and if they occur they seldom entirely subside until the bowels have acted. They are, however, diminished by the administration of opium. Pain in the back is a very common complaint with people who have been in vigorous health before the operation, especially where the operation is prolonged, and where the patient has to lie on his back afterwards. This passes off in 24 or 36 hours, but while it lasts it causes considerable discomfort. A pillow or an india-rubber hot water bottle under the back relieves it to some extent, and where we expect that it may happen, *e.g.* in prolonged operations, it is well to place a pillow under the loins when the patient is put upon the operating table.

In cases where asepsis is obtained, the patient is free from pain by the next day at latest and rapidly regains his normal strength, very little further attention being required. If the operation has been a severe one, it may be well for 48 hours after the operation to keep him on slops, that is to say, beef-tea, chicken broth, milk, a little champagne or other stimulant, etc., and then on the third day to commence solid food, and in a day or two to let him have his ordinary diet. Where the operation has not been severe, and there has been no sickness, no restriction need be placed on the diet after the first 24 hours.

Aperients.—The patient is seldom quite comfortable until the bowels have been cleared out, and this should generally be seen to on the second

or third day after the operation. The best plan is the administration of a dose of castor oil in the evening, followed by a seidlitz powder or an enema in the morning. This, of course, does not apply to such operations as those upon the rectum, etc., where it is often essential to keep the bowels confined for some days. Certain special points, such as the time to allow a patient to get up, etc., will be noted under individual operations.

CHAPTER VII.

WOUNDS.

MODES OF HEALING.

It may be well, before discussing the treatment of wounds, to refer very shortly to the modes in which they heal. There are five methods by which healing may take place, namely: healing by first intention, by blood clot, under a scab, by granulation, and by union of granulations. The particular form of healing which occurs depends, in the first place, on whether the edges of the wound are brought together or remain apart, and, in the second place, on whether causes of suppuration gain access to the wound, either at the time of its infliction or at some subsequent period.

The immediate result of the infliction of a wound is bleeding, and blood clot forms on the cut surface. When this clot is wiped off it is found that exudation is taking place beneath; in other words, as the result of the irritation of the knife and the contact of foreign bodies, a narrow microscopic layer of inflammation, going on as far as the end of the first stage—namely, exudation—has been set up. The result in all wounds, whatever their nature, whether the edges are brought together or not, is that lymph (*i.e.* coagulated fibrin entangling white corpuscles) is poured out and glazes the surface.

Healing by "First intention."—Where no further causes of inflammation come into play, notably where no bacteria are present, this lymph remains, and if the edges of the wound are brought into apposition, it glues the two surfaces together. It then soon becomes infiltrated with cells: at first leucocytes, and, later on, larger plasma cells pass into it. These plasma cells apparently feed on the remains of the white corpuscles and destroy them, and they themselves enlarge, become spindle-shaped, and form young fibrous tissue. The result is that, while after the first 24 hours the two cut surfaces are separated by a layer of young cells, in the course of three or four days the cells have become spindle-shaped and some of them are already forming young fibrous tissue. New blood-vessels are also developed very much in the same manner as in the embryo. As time goes on, the fibrous tissue between the two cut surfaces

becomes more perfect and contracts, thus shortening the incision and temporarily depressing its surface; the newly-formed vessels also tend to disappear. Later on this new fibrous tissue, where it is situated in the middle of fat, becomes itself converted into areolar tissue, fat cells form in it, and the scar becomes looser.

The epithelial cells on the surface begin about the second or third day to multiply and spread over this narrow line of young cellular tissue, so that, in most cases, at the end of the fourth or fifth day, there is a continuous layer of epithelium from one edge of the wound to the other. This process is termed primary union, or healing by first intention, and it ought to be aimed at in all cases, because in connection with it there is no general disturbance, no fever, and no septic trouble, while the resulting scar is small and after a time almost unnoticeable.

Healing by blood clot.—Where the edges of the wound are not in apposition, the space between the cut surfaces becomes filled with coagulated blood, whilst the surfaces themselves are covered with lymph. Under certain circumstances, where no further causes of inflammation come into play, this blood clot remains and forms a mould in which the young cells (the plasma cells) develop and form fibrous tissue and fresh blood-vessels. After a time, when nearly the whole of the blood clot has become organized, epithelial cells begin to spread over this imperfect tissue from the sides. In the case of small wounds it is often found at the end of about 14 days that a thin layer of the top of the blood clot can be peeled off, leaving an epithelium-covered surface beneath. This process may be termed healing by blood clot, and although it is only visible when the edges of the wound do not come together, it occurs to a greater or less extent in almost all wounds of any depth, because the deeper parts of a wound are seldom in such accurate contact that only a thin layer of lymph divides them; where there is any appreciable separation, blood clot forms between the raw surfaces, and undergoes organization in the manner just described. Hence, even in wounds that heal by first intention, that process as a rule only takes place towards the surface, while the deeper parts heal by blood clot.

Healing under a scab.—The process of healing by scabbing is practically the same as healing by a thin layer of blood clot. The superficial layer of lymph and blood dries up and forms a scab, which protects the surface of the wound from irritation, and organization goes on in the thin layer of lymph beneath, while epithelial cells spread in underneath the scab.

Healing by granulation.—Where wounds are irritated, or where sepsis is present, healing takes place by granulation. Where this happens the edges of the wound have either not been brought together, or, if they have, union by first intention has failed, owing usually to the occurrence of sepsis. As in both the preceding cases, effusion of lymph occurs as the first change, but the process of inflammation does not stop there. Since the causes of irritation continue to act, the inflammation goes on to the

second stage, namely, granulation, so that all the structures exposed in the wound become converted into granulation tissue, and the original tissue disappears. This granulation tissue soon becomes arranged in the form of little rosy buds, termed granulations, which on microscopical examination are seen to be composed of embryonic cells with numerous young blood-vessels. These granulations continue to grow and ultimately fill up the wound, and when they are nearly on a level with the skin, epithelium begins to spread over their surface.

While this process is going on, the cells of the granulation tissue in the deeper parts of the wound, being protected from irritation by the granulations on the surface, develop into young fibrous tissue, and the blood-vessels become obliterated in large numbers. This young fibrous tissue at once begins to contract, and this contraction results in the drawing together of the edges of the wound, so that, even before the spread of epithelium has commenced at the surface, the wound may be very much smaller than it was when first made.

When the young epithelial cells begin to spread over the surface, a delicate red line is found around the edge of the sore, because at first the epithelial cells are young, transparent, and only in a single layer, and therefore they allow the red colour of the granulation tissue to show through. At a later period the epithelium becomes thicker, and a bluish appearance is the result; still later, when the epithelium has been formed for some time, the thick layer on the surface becomes macerated and white, like the skin of a washerwoman's hand, and there is a white line formed. Thus, in a healing wound, we have three zones—an outer white line shading off into a blue one, and that again shading off into a delicate pink one. In many cases this pink line is not noticeable until the wound has been dried, when it will be seen that, while the granulations on the surface of the unhealed part begin to ooze and become moist, the red line at the edge of the wound remains dry. The detection of this red line is of great importance, because it implies that healing is in active progress.

The ultimate stages of healing by granulation consist in the new epithelium becoming thicker and thicker over the surface, so that for some weeks epithelial scales are constantly forming. Later on the wound contracts, and this contraction may lead to very serious deformity. The structure of the scar undergoes continued alteration until ultimately it is composed of a mass of fibrous tissue covered with epithelium, and containing very few blood-vessels; but there is no development in it of the special structures of the skin, such as hairs and sebaceous or sweat glands.

During the process of healing by granulation, the patient is exposed to the risk of severe local and general troubles arising from the various infective diseases due to bacteria, which may gain entrance through the open wound. These will be described in their proper place. In any case, unless the wound be aseptic or very small, there is a certain amount

of fever ("traumatic fever") during the period of the formation of the granulations, due to the absorption of poisonous products from the decomposition in the wound. When granulation is complete, that is to say, about the third or fourth day, the temperature falls and the fever disappears, because the granulations do not permit absorption of these poisonous products.

Apart from the danger of sepsis, a drawback to this mode of healing is that the scar is larger than after healing by first intention, and the deformity due to the contraction of the scar is sometimes very serious; it is evident, therefore, that healing by granulation is not such a desirable process as is union by first intention.

Healing by union of granulations.—Lastly, there is another mode of healing which was at one time much encouraged, namely, healing by union of granulations. Here the edges of the wound are not brought together in the first instance, but are kept apart with dressings until both surfaces are granulating, and then, when granulation is complete, the surfaces are purified and brought together. The result is that over a considerable area these granulating surfaces adhere, and union occurs rapidly; but the risks attendant on healing by granulation, to which reference has just been made, apply to this method of healing also. It is not a mode that should be deliberately chosen when other methods are available, but it is well to bear in mind that granulating wounds may unite if their edges are brought together.

Conditions inimical to healing by first intention.—In order to obtain healing by first intention (which should always be aimed at in incised wounds), it is essential, in the first place, to bring the edges of the wound together, and, in the second place, to avoid anything which may lead to inflammation. Among the minor conditions which tend to prevent union by first intention are, firstly, mechanical irritation of the part, more especially in the form of movement either of the part itself or of the muscles beneath it; secondly, the presence of too tight stitches; thirdly, the irritation of dressings, or of the chemical substances contained in them, or used as lotions. The most common cause, however, which leads to the failure of union by first intention or by blood clot, and which exposes the patient to the various serious risks which will afterwards be mentioned, is the entrance of micro-organisms and their growth either in the material on the surface of the wound or in the tissues themselves. The organisms which act in this way are essentially the pyogenic organisms, and they consist of various kinds of micrococci, known as the pyogenic cocci, the chief of them being the staphylococcus pyogenes aureus, staphylococcus pyogenes albus, and streptococcus pyogenes. These organisms growing in a wound peptonize the materials on the surface, and so lead to the destruction of the original tissue, while they produce chemical substances of great potency, which act locally by causing first granulation, and subsequently suppuration, and, generally, by setting up febrile disturbance.

These micro-organisms are normally present in most cases on the surface of the skin and mucous membranes, more particularly in parts where the skin is moist, as, for example, in the perineum, the axilla, between the toes, in the dirt under the nails, and so forth. They grow in the old epithelium on the surface of the skin around the hairs, and they also appear to penetrate into the orifices of the sebaceous and hair follicles. They vary in virulence, and the different kinds vary also in their mode of action. For example, the staphylococci seem especially to cause the circumscribed abscesses, whereas the streptococci creep among the tissues, causing diffuse cellulitis, and gain access to the blood stream and set up pyæmia.

The great object of wound treatment is, therefore, to prevent the entrance of these organisms into the wound, or, in cases where this is impossible—as, for example, in operations about the mouth or the rectum—to interfere with their growth, and thus to minimise their evil effects as far as possible. With the view of preventing the entrance of these organisms into the wound, various antiseptics must be employed. Various substances are now known which kill the organisms, some of them with rapidity, and, fortunately for us, the organisms which cause the mischief in wounds are, with few exceptions (notably the tetanus bacillus), non-spore-bearing, and hence are very readily killed even by dilute antiseptic solutions. A 5 per cent. carbolic acid solution will destroy these pyogenic cocci in a few seconds, provided always that it is enabled to gain proper access to them; similarly a 1-2000 sublimate solution will act very quickly. It is essential, however, that these solutions be able to gain free access to the organisms. It must be remembered, with regard to these and some other antiseptics, that they coagulate albumen, and thus organisms protected by this layer of coagulum may escape their action. Heat of course is a most potent agent in the destruction of bacteria, both dry heat at a temperature of 130° C. (280° F.), and moist heat in the form of water at the boiling point. To boil instruments, or any other materials for a sufficient time, will thoroughly disinfect them. This point will be more fully referred to in dealing with the disinfection of instruments (see Chap. VIII.).

CHAPTER VIII.

WOUNDS.

TREATMENT OF INCISED WOUNDS.

CLASSIFICATION OF INCISED WOUNDS.—There are two great classes of incised wounds, those made by the surgeon, and those inflicted before the patient is seen by him. Wounds made by the surgeon may be again subdivided into:—(*a*) those made through unbroken skin and not communicating with mucous surfaces; (*b*) those made in connection with previously existing sinuses or suppurating deposits, or communicating with some mucous canal. The importance of this subdivision is that, while it is a comparatively easy matter to exclude micro-organisms from wounds of the first class, it is either very difficult or altogether impossible to do so in the second variety; the treatment in the latter must therefore be directed towards minimising the ill effects produced by the organisms after they have gained entrance.

WOUNDS MADE BY THE SURGEON THROUGH UNBROKEN SKIN.

It is clear from what has gone before that the point to be aimed at here is healing by first intention. If this be obtained, there is rapid recovery and a delicate scar is left, which later on becomes practically invisible, while the general septic conditions or the local inflammatory troubles which may occur if union by first intention be not obtained, are avoided.

The conditions which favour healing by first intention have already been referred to (see p. 150); of these, one that is absolutely essential is the asepsis of the wound; in addition to this, however, care has to be taken to bring the edges of the wound into accurate apposition. Besides this, causes of unrest, such as movement, irritation by the dressings, etc., must be avoided. We shall consider these latter conditions first.

Apposition of the Edges.—The edges of the wound must be in accurate apposition; if they are not in contact with one another, an interval is left which becomes filled up with blood clot, and although healing by blood clot will occur if the wound be aseptic, it is not so good as union by first

intention. In placing the edges of the wound in apposition, care should be taken to see that one edge is not on a higher level than the other. Should this occur to a very slight extent it will not matter, except in so far that the subsequent cicatrix is not a fine delicate line, but shows a definite ridge. If, however, there be any marked difference in level between the edges, and more especially if the raw surface of the one side chance to lie in contact with the cutaneous surface of the other, healing of the overlapping raw surface will not take place although the deeper parts will unite satisfactorily enough. It is a curious fact that epithelium will not spread over a raw surface which is lying in contact with epithelium-covered skin, and where an overlapping of the kind alluded to is present, it is necessary, in order to obtain proper healing, to pare away the inverted or overlapped edge of the skin, and thus to have two raw surfaces opposed to each other.

Approximation of Deeper Structures.—When a wound has to be closed it is important to remember that its deeper parts must be approximated as well as its cutaneous edges. For this purpose some surgeons employ deep stitches and then put in superficial ones to bring together the skin and the more superficial structures; this is however hardly necessary in the large majority of cases. By properly applied pressure outside the wound (see p. 170), it is, as a rule, quite possible to bring the deeper parts sufficiently together, and stitches need only be employed for the approximation of the edges of the skin.

Sutures.—The choice of the particular material that is to be used for stitches is determined by the asepticity of the wound and the amount of tension upon its edges. As we are now dealing only with aseptic wounds, we have merely to consider what materials are suitable for stitches in (*a*) those where there is no tension on the edges; (*b*) those where the tension is very great, and (*c*) those where it is only moderate in amount. It is also well to bear in mind, more particularly in connection with wounds on exposed parts, such as the face, neck, etc., that where there has been healing by first intention more unsightliness is produced by the stitch marks than by the cicatrix itself; therefore, under these circumstances, the avoidance of stitch marks is a matter of considerable importance. Whatever be the material used for stitches, it should be kept in a 1-20 carbolic lotion for at least several hours before the operation, and then washed in 1-2000 sublimate solution immediately before it is used.

(*a*) **Where there is no tension.**—Where there is no tension on the edges of the wound, and where as delicate a scar as possible is desired, as in operations upon the face and neck, the finest material only should be used, and the stitches should not be put closer together than is absolutely necessary to keep the edges in contact; and further, they should be inserted as close as possible to the line of incision. Under these circumstances fine *horse-hair* is probably the best material to employ. The size of the stitch marks may be still further reduced if a fine Hagedorn's needle be

employed. This form of needle is flattened from side to side, so that it makes its skin puncture at right angles to the edge of the wound, and as the stitch is pulled tight, its tendency is to close the small hole, whereas with the ordinary curved needle, which makes an incison parallel to the edge of the wound, the effect of tightening the suture is to enlarge the incision and consequently to leave a larger scar.

How to avoid Stitch Marks.—In many cases of small wounds, such as those upon the face, it is possible, by taking a little trouble, to avoid stitch marks entirely. The best plan is to approximate the deeper part of the dermis by buried sutures, and when this is done the superficial part can be brought accurately together by strips of gauze fixed in position by flexile collodion. The best way of introducing a buried suture is to take a curved Hagedorn needle threaded with the finest *catgut*, and pass it through the fat and deeper part of the dermis on one side of the wound, and then through the fat and deeper part of the dermis on the other,

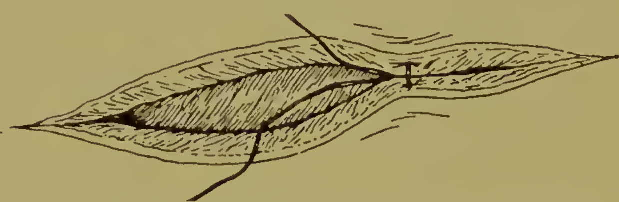

FIG. 45.—A BURIED SUTURE. The figure shows how, by making the free end of the suture emerge on each side through the deeper part of the dermis and the adjacent subcutaneous tissues, the knot can be easily pushed out of the way among the fat when it is tied. If it were done in the reverse way the knot would lie between the lips of the incision, and would interfere with perfect coaptation. The ends of the suture are cut off quite short and pushed down out of the way by means of a probe.

the needle being made to enter the fat and emerge through the dermis on the one side, and *vice versâ* on the other. Several stitches are passed, and they are then tied and the ends cut short, the knot being pushed down into the fatty tissues beneath the dermis (see Fig. 45). These sutures hold the deeper parts of the skin firmly together. A strip of gauze is then fixed upon one side of the wound with collodion, and when it is dry the skin on the other side is pressed inwards towards the line of incision, and the free end of the gauze strip is fastened down upon it with collodion. As far as the gauze and collodion are concerned, the procedure closely resembles the old-fashioned method of applying strapping to draw the edges of wounds together, and is similar to the plan adopted in hare-lip operations. By its means the epithelial edges are approximated, and stitch marks are absolutely avoided, so that only a very delicate linear scar is left, which in a short time becomes quite unnoticeable. Where there is no special reason for avoiding stitch marks, the best plan is to close the wound by a continuous button-hole stitch of fine *silk* (see p. 158).

(*b*) **Where there is great tension.**—In many cases, after operation for the removal of tumours, etc., as, for example, after excision of the breast, there is a considerable deficiency of skin, and the result is that the edges of the wound will not come together without considerable traction.

If the skin be pinched up by a stitch that is too tight, persistent irritation is caused, and perfect union may fail; at any rate it will not be so rapid and firm as it should be. It is therefore very important, when inserting sutures, to see that no stitch is tighter than is absolutely necessary to approximate the edges of the skin. Where there is much difficulty in bringing the edges together, however, a certain amount of irritation must necessarily be caused by the stitches, but this can be to a great extent reduced by introducing a few so-called "stitches of relaxation" (Lister), at some considerable distance from the edges of the wound. The tension upon these may be great, and they may subsequently to a certain extent cut through the soft parts; but, temporarily at any rate, they serve to relax the edges of the wound, which may then be stitched together without any tension, with the result that they will heal by primary union. Hence, two classes of sutures are used in cases where the edges of the wound require to be pulled together, namely, a set of stitches of relaxation, and others which may be termed "stitches of coaptation."

"*Stitches of Relaxation.*"—Stitches of relaxation are employed, then, for the purpose of taking off the strain from those of coaptation, and they require to be inserted at a considerable distance from the edges of the

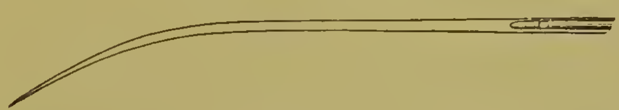

FIG. 46.—LISTER'S NEEDLE. The groove for the reception of the wire is seen beyond the eye of the needle.

wound, and must be reasonably stout, because a thin stitch would cut its way out too quickly; the best material for this purpose is thick *silver wire* (the most suitable size being that commonly sold as No. 1 or No. 2). Special *needles*, "Lister's pattern" (see Fig. 46), must be employed for introducing them. In these needles the wire is threaded through an eye at some distance from the end, while between the eye and the end of the needle there is a groove, into which the wire is pressed, so that where the needle goes the wire follows without any unnecessary tearing of the structures through which it passes. In threading these needles, two or three inches of the wire are passed through the eye and flattened into the groove; the end of the needle is then held with forceps, and the two ends of the wire are carefully twisted together (see Fig. 47). If one end of the wire be merely twisted round the other, a number of irregularities are left, which catch in the wound when the stitch is pulled through. Another point with regard to the use of silver wire for this purpose may be mentioned. Pure drawn silver wire without any alloy must be employed, and if it kink it must not be straightened by passing it between the finger and thumb, as is so often done. This destroys the suppleness of the wire at once, and it cannot be tied into a knot; each end should be grasped in a pair of forceps, and the wire straightened by pulling upon

them. The portions grasped by the forceps are then cut off, and the wire is ready for use. If the suppleness has been lost, it can be immediately restored by passing the wire through the flame of a spirit lamp.

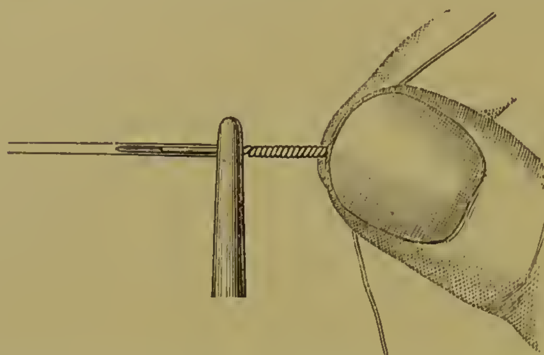

Fig. 47.—Method of Threading Lister's Needle with Wire. The needle is shown grasped at the extreme end by a pair of dressing forceps. The forceps held in one hand serve to fix the needle and to flatten the wire into its groove while the wire is carefully twisted up with the fingers of the other hand. The twists should always be close and regular, as in the figure, or they will be liable to catch in the skin.

In order to fix wire stitches of this kind, if the tension be not very great, the first half of a reef knot should be tied, the ends turned up at

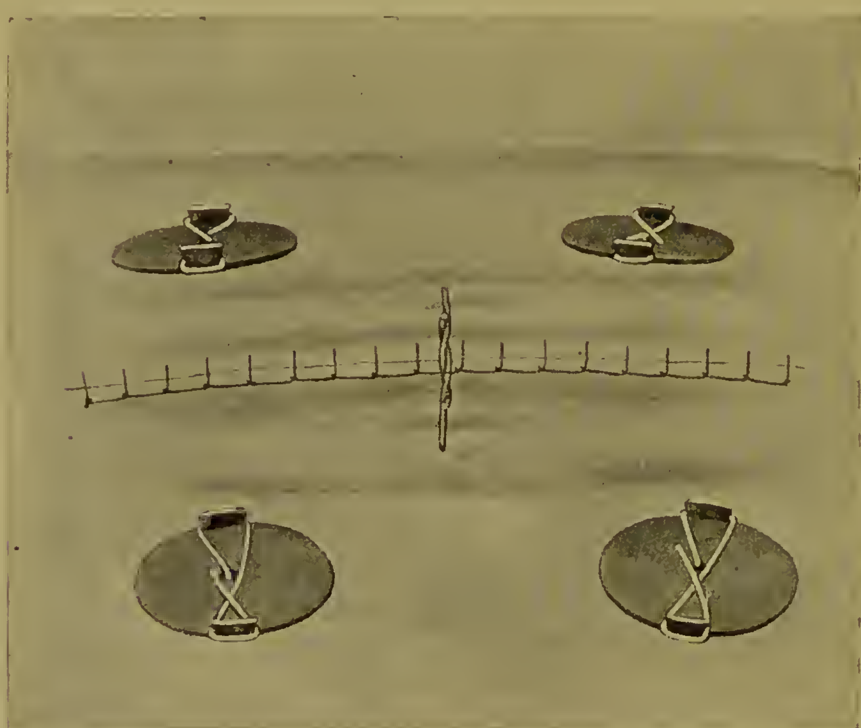

Fig. 48.—Method of Suturing a Wound where there is much Tension on the Edges. On either side is a pair of button sutures, showing the figure-of-eight arrangement by which the wire is fastened. In the centre is a relaxation stitch of stout silver wire showing the manner in which the wire is tied and its ends clipped off. A continuous "button-hole" stitch unites the edges of the skin which, by the aid of the button sutures and the silver wire stitch, come together without tension. The puckering of the skin caused by the tension upon the button sutures and silver wire stitch is also indicated. The skin has been freely undermined.

right angles, and then clipped off flush with the surface of the wire (see Fig. 48); if the wire be stout, this will hold perfectly well, while

there is no projecting end left to catch in the dressing. Where the tension is great, a second twist must be made, and the ends cut off and bent down on to the skin. All chance of the wire catching in the dressing may be avoided by interposing a layer of oiled silk protective between the latter and the wound. A sufficient number of these deep silver wire stitches must be put in to enable the edges of the wound to be brought together without any tension.

Undermining Flaps.—Where much skin has been taken away, the edges cannot usually be brought together properly with stitches unless the skin be widely freed by undermining it. By this means the skin and fat are separated from the deeper parts for a considerable distance, sometimes for a good many inches, and the elasticity of the skin allows the flap of skin thus formed to stretch, and the cut edges to meet (see also p. 178).

Button Sutures.—Where the tension is very great, the "button sutures" introduced by Lord Lister may be employed with advantage. A needle threaded with stout silver wire (see above) is inserted through the skin several inches from the edge of the undermined flap, at the outer limit of the undermining, and the free end of this is attached to a lead button (see Fig. 48). The wire is then carried across the wound, and the needle brought out through the skin at the corresponding spot on the opposite side where the undermining ceases. The needle is then cut off, and over the cut end of the wire is threaded a second button, which is pushed as far down as possible, while firm traction is made on the wire, and the latter secured in place. Only a few of these button stitches need be put in; as a rule, in a breast case, two pairs are sufficient. The larger the button used the better; the pressure is then more evenly distributed over the skin, and there is less likelihood of sloughing. If a small button be employed, the skin may very possibly slough where the button presses upon it; in any case, a small slough generally forms where the wire penetrates the skin, but this causes no trouble if the wound be aseptic, and it heals readily when the buttons are removed. Several stitches of relaxation will also be required to support and take off tension from the edges of the wound. These will be inserted about midway between the buttons and the edge of the wound (see above).

The button stitches are usually left in for about five or six days, and they are the first sutures to be removed, partly because the skin will not retract after being stretched for that length of time, and partly because if they are left in longer they are apt to cause a slough.

(*c*) **Where there is moderate tension.**—Where the traction required to bring the edges together is only moderate, a very good material for a stitch, and one that is intermediate between one of relaxation and one of coaptation, is *silkworm or fishing gut.* This is fairly thick, and, if a good hold of the skin be taken, the latter can be made to bear a considerable amount of tension without bad results.

"*Stitches of Coaptation.*"—For the stitches of coaptation, that is to

say, the stitches employed to bring the edges of the wound accurately together, it was formerly the practice to use interrupted sutures, each suture being separately inserted, knotted and divided. Of late, we have employed a continuous suture, which has the advantage that the edges are more accurately approximated and that the suture is much more rapidly inserted, a point that is of great importance when, at the end of a long or severe operation, a large wound requires to be closed.

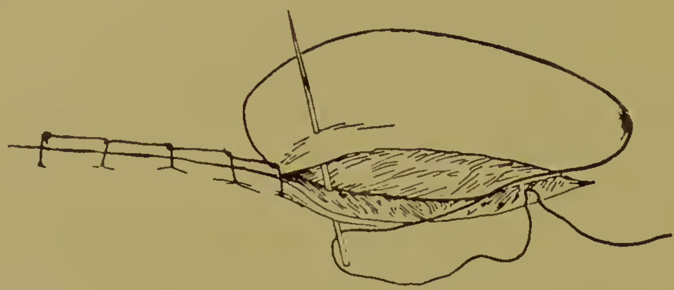

FIG. 49.—BUTTON-HOLE OR BLANKET STITCH. The figure shows the thread looped hehind the needle as it emerges from the skin. The first loop of the suture—at the left-hand end of the figure—is knotted in the ordinary way; the remaining loops are made as shown at the right-hand end.

The best form of *continuous suture* is that resembling the blanket or *button-hole stitch* (see Fig. 49). In the first place an ordinary suture is

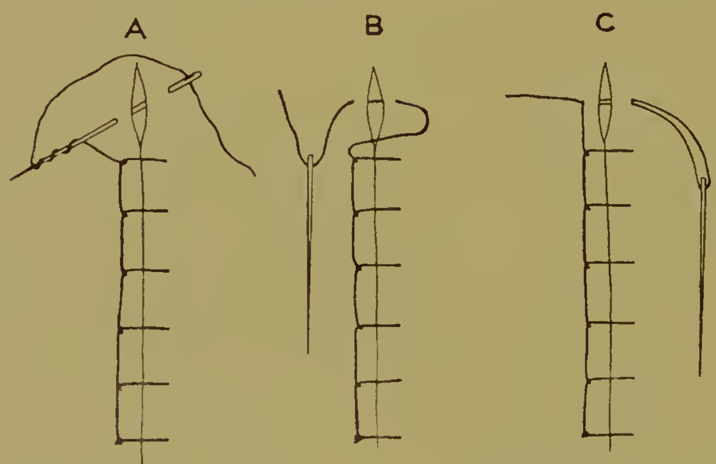

FIG. 50.—METHODS OF FINISHING OFF THE BUTTON-HOLE SUTURE. *A*. As the needle emerges through the skin for the last time, the thread is twisted around it three or four times. The needle is then pulled through and the stitch pulled tight. A perfectly satisfactory knot can he thus made with a little practice. *B*. Shows a method very commonly used. When the needle is passed through the skin for the last time it is not brought out inside the loop from the last stitch; the free end shown on the left-hand side of the incision is taken in one hand, the loop shown on the right-hand side in the other, and the two are then tied together. This is a simple method, hut causes a little puckering. *C*. Shows the method employed hy Professor Rose to ohviate this puckering. In passing the needle through the skin for the last time it is made to go in the opposite direction, *i.e.* in the diagram from left to right, whereas the rest of the stitch is made from right to left. The free end shown on the left-hand side of the incision is then held in one hand while traction is made upon the needle with the other; the result is that the last loop is drawn tight and the wound is closed. The free end on the one side and the loop—or the two free ends if the needle he cut off—on the other are then tied together. This is a very simple and effective plan.

inserted and tied, to prevent the suture slipping; then, instead of cutting the suture, the needle is passed through the two edges of the wound, and brought out inside the loop formed by the thread, and drawn tight, and

this is continued till the whole wound is stitched up; the end may be secured either by leaving the last loop long and tying a knot between it and the free end of the thread, or by taking several turns of the thread around the needle as it forms the last loop and then tightening it up (see Fig. 50). The result is that along one side of the wound there is a continuous thread of silk, which acts very like the old quilled suture. This stitch is better than the herring-gut stitch, which was at one time frequently employed in uniting intestine, and which tends, if drawn at all tight, to pucker up the edges, and may even cause gangrene of portions of them. If the dressings have been allowed to dry, the threads will, after a few days, be found stuck together with blood, and if any one of the stitches be too tight, it can be divided or removed without the rest of the stitch necessarily giving way. The best material for the continuous suture is silk, of the variety known as Chinese twist, varying in thickness according to the amount of tension to which it is exposed. Where there is no tension, quite a fine silk is sufficient; but where there is much, it is better to use silk of medium thickness, as the fine thread cuts out very quickly under these circumstances.

Summary of methods of Suturing Wounds.—What has been said with regard to stitches may be summed up as follows. Where there is no tension on the edges of the wound, and a very small fine scar is required, either buried sutures may be used, with no sutures in the skin at all, or the finest horse-hair may be employed. Where very great tension is present, button sutures should be used, after undermining the flaps, and in addition to them, deep relaxation stitches of silver wire should also be inserted, these being sufficiently numerous to support the edges of the flap, which should be coapted by a fine continuous button-hole stitch. Where there is only a moderate amount of tension, interrupted silkworm gut stitches, reinforced by a fine continuous coaptation suture of silk, may be made use of; and lastly, where there is little or no tension. and where stitch marks are unimportant, the edges may be approximated by means of thick or fine silk.

Removal of Sutures.—It has already been said (see p. 157) that button sutures should be removed in about five or six days. Where there are also silver relaxation stitches, and the wound is dressed for the purpose of removing the buttons, the continuous silk suture can as a rule be taken out at the same time, only the deep silver stitches being left. The removal of these latter must depend on the firmness of union between the edges, but generally they can all be taken out at the end of a week or ten days. If there be any point where the strength of the union is doubtful, as for instance where a triangular flap of skin has been dragged up to meet two other flaps, the stitches at the apex of the flap should generally be left for about a fortnight. With the exception of cases where button sutures have been used, there is no necessity to dress the wound for the purpose of removing any stitch before firm union has occurred, and

we seldom dress a wound until about ten days after the operation, unless these sutures have been employed.

Avoidance of Movement.—The importance of avoiding movement of any part in which healing by first intention is aimed at, has already been referred to (see p. 150), and this should be provided for in all wounds. In operations on the extremities, a suitable splint must be applied to control the movements of the neighbouring joints, and this should be kept on for about a week or ten days. In operations upon the abdomen a firm binder will usually ensure rest, if the patient be forbidden to sit up. In breast operations the arm should be so fixed that the pectoral muscles are kept at rest. In operations about the neck, it is usual to put on an extra amount of dressing, which is firmly fixed with a bandage, so that, when the deeper part becomes stiffened by the dried blood, and is supported by the large mass of dressing outside it, it practically forms a splint for the head and neck: some surgeons employ a specially moulded collar of poroplastic material or guttapercha, but this is rarely necessary.

Avoidance of Irritation.—Care must also be taken to prevent irritation of the wound by antiseptic solutions or dressings; but if a wound be not dressed till it has healed, as is our usual rule, there will of course be no irritation resulting from antiseptic lotions. The chief point of importance, therefore, centres in the choice of the dressings, which must not exert any chemical or mechanical irritation. With regard to the former point, care is taken that the gauze placed next the wound shall not contain any soluble irritating antiseptic substance; this will again be dealt with immediately. The mere presence of the gauze over a wound, the edges of which have been properly brought together, does not at all interfere with healing by first intention, particularly if the wound be left undisturbed for a week or ten days. Where silver stitches are used, the ends of the wire are very prone to become entangled in the gauze, and any movements of the patient may drag upon them; this can be avoided by interposing, between the line of incision and the gauze dressing, a narrow strip of Lister's protective oiled silk, previously sterilised by immersion in 1-20 carbolic lotion and then washed in 1-2000 sublimate solution immediately before being applied. Where button stitches are used, each button should also be covered with a piece of this material, but care must be taken that the dressing overlaps the latter for a considerable distance in all directions; if not, sepsis may very readily spread in beneath it.

Exclusion of Micro-Organisms.—The next point in the treatment of wounds, namely, the exclusion of micro-organisms, is most important; indeed, it is the really essential one. Even if the steps necessary for the exclusion of micro-organisms were to interfere with healing by first intention, it would still be incumbent on the surgeon to see that they were carried out, on account of the disastrous results that follow the entrance of micro-organisms into a wound. As a matter of fact, however, they can be

excluded without in any way interfering with healing by first intention. The exclusion of organisms during and after the performance of an operation is the essential Listerian principle, and at the present time two plans are adopted for carrying it out. One is that which was originally introduced by Lister and has since undergone many modifications; it consists in the preliminary disinfection of skin, hands, instruments, etc.; in the use of antiseptic substances during the course of the operation; and in the subsequent application to the wound of dressings containing antiseptics. In the other method (sometimes termed the "aseptic" method), while in the preliminary stages the procedures are essentially the same, the use of antiseptic substances during the course of the operation and afterwards in the dressings is avoided (see p. 173). There is no real antagonism between the two plans; it is merely a difference in the mode by which the same end is attained. In our opinion, the exclusion of micro-organisms is attained in practice much more certainly by the use of antiseptics than by the other plan.

Sources of Infection by Micro-Organisms.—Micro-organisms may enter a wound firstly from the skin in the neighbourhood of the wound itself; secondly, from the hands of the operator or his assistants; thirdly, from the instruments, ligatures, etc., that are used during the course of the operation; and fourthly, from the air. The first three of these sources must receive special attention, and, if they be properly guarded against, it will practically always be possible to obtain an aseptic wound. The organisms which fall in from the air are usually non-pathogenic, and will not grow in a wound the walls of which are brought properly into contact during healing.

Disinfection of the Skin.—Micro-organisms are always present in the skin and are most numerous where it is moist, as, for example, in the axillæ, in the perineum, between the toes, and in the various folds of the skin. They are found not only in the old epithelium upon the surface, but also about the hairs, and they seem to penetrate to a certain distance into the hair follicles and sebaceous glands; hence their complete eradication is a matter of some little difficulty. In order to get rid of them, antiseptic substances must be used, whichever of the two methods referred to above is to be employed. In the first place, the skin for a considerable distance around the area of the proposed operation wound should be shaved, and the grease which is present on the surface of the skin, and which prevents the action of most antiseptic solutions, must be removed. This may be effected by means of turpentine, benzine, ether, alcohol, etc. We prefer turpentine, which is a very efficient solvent of fat, while at the same time it possesses a certain, though slight, antiseptic action. After the skin has been shaved it should be well rubbed with turpentine, and this should be done with special thoroughness when the operation is in the neighbourhood of parts that are normally hairy, as, for example, the axillæ or the pubes. After this the part is thoroughly washed and scrubbed with

soap and 1-20 carbolic acid solution, or still better, a 1-20 watery solution of carbolic acid containing $\frac{1}{500}$th part of corrosive sublimate (this we have already referred to as the "strong mixture"). This cleansing should be done with great thoroughness, and several minutes should be devoted to it; in the first place the washing should be done with the hands, and afterwards the skin should be scrubbed with a nail-brush which has been soaked for some time in the strong mixture. Indeed, wherever it can be managed, the purification of the skin should take place some hours before the operation, and a piece of gauze soaking in 1-20 carbolic acid solution should be fixed over the part so as to prolong the disinfection; in any case, however, the process should be repeated immediately before the operation. Before the incision is made the strong mixture remaining on the surface of the skin should be washed away with a 1-2000 sublimate solution. It is always necessary to purify a wide area of the skin all around the neighbourhood of the operation wound.

Precautions.—In children or those suffering from pyrexia (for example, hectic fever), it is advisable not to wrap the part up in a carbolic dressing after disinfection, as the drug is very apt to be absorbed and may lead to dangerous symptoms of poisoning. The carbolic acid must no doubt be used for the disinfection of the skin immediately before the operation, but then only very little if any absorption will occur; in these cases the wet gauze or cloth which is afterwards put on to continue the disinfection should be simply soaked in a 1-2000 sublimate solution.

Disinfection of the Hands.—The disinfection of the hands of the operator and his assistants is also a point which must be scrupulously attended to. Special attention must be directed to the thorough cleansing of the nails, by the removal of the dirt beneath them, and of the old dead epithelium in the folds about them. The disinfection should not be limited to the fingers, but should involve the whole hand, wrist and forearm, as far as the elbow. It must be carried out in precisely the same manner as that employed for disinfecting the patient's skin: first by washing the hands thoroughly with hot water and soap, then soaking them with turpentine, and finally using a nail-brush with soap and strong mixture. The nails should be cut short, and all dirt and epithelial *débris* beneath and around them removed by a suitable nail-cleaner. The process of disinfection should last at least ten minutes, and after it is complete, the hands should not be dried upon a towel, but should be rinsed in a 1-2000 sublimate solution, and a basin of this should be at hand so that the hands may be frequently dipped in it during the course of the operation. It is very often the custom after disinfecting the hands to wipe them on a dry towel, but unless the latter be perfectly aseptic, this is simply to cover them again with dust. We strongly recommend that the hands should never be allowed to dry after disinfection, but should always be kept wet with a 1-2000 sublimate solution, the blood being frequently washed off the hands by means of this solution during the course of the operation.

Disinfection of Instruments.—The purification of instruments is carried out as follows. After an operation they are thoroughly washed and cleaned by means of a nail-brush, immersed in a 1-20 carbolic acid solution, dried and put into a press with glass shelves where they can be kept free from dust. If they have been used for a septic case, they should be boiled before being put away, otherwise the instrument case itself may become contaminated. If this be done, there is not much disinfection required immediately before use, and it will suffice in the majority of cases to immerse the instruments in a 1-20 *carbolic acid* solution for half an hour or longer before the commencement of the operation. Where there is not sufficient time for prolonged immersion of the instruments in the carbolic acid solution, or if the nature of the case demands extra precautions, they may be disinfected by dipping them for a few minutes in undiluted carbolic acid, and subsequently immersing them in a 1-20 carbolic solution. This can readily be done by pouring out a sufficient quantity of the pure acid into a jar or dish, dipping the instruments into it, and then transferring them to the 1-20 solution. This latter method is also the best where an instrument is required in a hurry during the progress of an operation, and where there is no time to boil it or to immerse it in the lotion for a sufficient length of time.

Boiling instruments is doubtless a very certain method of disinfecting them, and is to be strongly recommended where it can be carried out, and where the instruments are entirely metal. It is very readily done by placing them in a sheet or bag of gauze, and immersing them in a vessel of boiling water to which a little soda has been added. Special 'sterilisers' are sold for the purpose; they are provided with a perforated tray which, like the sheet of gauze, enables the instruments to be removed easily when they have been boiled for a sufficient length of time. They should be kept at the boiling point for at least ten minutes, and should then be transferred to the 1-20 carbolic solution. Prolonged boiling of this kind is apt to destroy the cutting edge of steel instruments, and for them pure carbolic acid or a prolonged immersion in the 1-20 solution is preferable. It is also well, when steel instruments are to be disinfected by boiling, not to immerse them until the water is actually boiling; this avoids discoloration.

Preparation of Ligatures.—The disinfection of the catgut, silk, silver wire, or other materials used for ligatures or stitches, may be effected by immersion in carbolic acid. It may be taken as certain that immersion in a 1-20 watery carbolic solution for from 24 to 48 hours will destroy any organisms to which the fluid has free access. Our rule is therefore to keep these materials constantly in this solution, which is renewed every three or four days on account of the loss of carbolic acid, and we do not use any material that has not been soaking for at least a week. As soon as the supply is seen to be running short a fresh quantity is put in, so as to always have enough ready for use. Some surgeons boil their silk before

the operation, but, while there is no objection to this procedure, it is unnecessary. As it is impossible to treat catgut in this manner (it would be spoilt by boiling), the method would involve treating the silk in one way and the catgut in another. If silk be boiled, it should afterwards be placed in a 1-2000 sublimate solution until it is required for use.

Preparation of Sponges.—The proper preparation of the sponges is of great importance. The most satisfactory method of removing blood from a wound is by the ordinary marine sponge; in our opinion, a much more satisfactory plan in many ways than the use of swabs of absorbent cotton wool, which have come very much into fashion of late years. In the first place, sponges soak up blood better; in the second place, when using swabs, shreds of cotton wool are apt to be left behind in the wound; and in the third place, the swabs as ordinarily prepared by nurses are very often septic.

After an operation the sponges are thoroughly washed, first with cold water to remove as much of the fibrin as possible, and then with soda and warm water; and it is well to leave them soaking in water for from 24 to 48 hours, rinsing them well once or twice during that time in order to free them more rapidly from the fibrin or mucus that has become entangled in them. At the end of the time they are again thoroughly washed and squeezed dry, and are then placed in a vessel containing a 1-20 carbolic solution. They should be kept in this for at least a week before they are again used, the carbolic being changed every second or third day on account of its loss of strength from the evaporation of the acid. If this be done, there is no objection whatever to the use of sponges, and they are much more convenient than swabs. The mode of cleansing them during an operation will be referred to immediately (see p. 166).

Swabs.—The only case where the use of swabs is advisable is where there is a foul septic wound, as in extravasation of urine, or in operations about the rectum, as, for example, in piles or fissure of the anus. If swabs be employed, they should be made of salicylic or plain absorbent wool, and wrapped up in gauze to prevent as far as possible threads of the wool being left in the wound, and when they are thus made they should be boiled. Before use it is well to squeeze them out of a 1-2000 sublimate solution, and indeed, if they are used for antiseptic work, they should be handed to the surgeon or his assistant in a bowl of this solution, out of which he should squeeze them himself. The nurse should never be trusted to do this, as she is very apt to soil them afterwards; the same remark applies to sponges (see p. 166).

Precautions during course of Operation.—Having in this way rendered aseptic everything coming in contact with the wound, further precautions must be taken during the course of the operation to see that no infection of the instruments, sponges, etc., shall by any chance occur; and the most essential of these precautions is to surround the area of the operation with towels rendered aseptic by being wrung out of hot antiseptic

solutions. If these **wet antiseptic towels** are placed all around the area of operation, instruments laid down upon them do not become contaminated, and the same is the case if the hands of the operator or his assistants rest upon them. It is well to see that the preparation of these towels is thoroughly carried out, and what is usually done at our hospitals is that the towels are boiled and then put to soak in hot 1-20 carbolic acid solution two or three hours before the time fixed for the operation; they are taken out of this immediately before use, immersed in a 1-2000 sublimate solution, and then lightly wrung out and applied directly to the field of operation. In private practice, except in operations of emergency, it is quite easy to instruct a nurse to have this done. When towels are prepared in this way, their asepticity may be thoroughly relied upon. When an operation has to be done in a hurry, it will suffice to thoroughly soak the towels in hot 1-2000 sublimate or 1-20 carbolic acid solution, provided they are not wrung dry. On the whole it is better, whether the towels are put to soak first of all in a 1-20 carbolic solution or not, to wring them out in a 1-2000 sublimate solution before they are laid around the operation wound. A solution of 1-20 carbolic acid, especially if it be not quite pure (as is commonly the case if obtained from the ordinary chemist), when applied to the skin, is apt to irritate it, and may be followed by absorption of the drug, whereas this does not occur when a 1-2000 sublimate solution is substituted.

The clothes and blankets in contact with the patient must be covered with **mackintoshes** (the most convenient are those made of thin jaconet), and outside these, towels, prepared as just described, should be spread in all directions, so that nothing can by any chance be laid on septic objects, such as blankets, sheets, etc. During the operation also the instruments should be handed to the surgeon direct from the antiseptic solution in which they lie, and although the small amount of carbolic acid which might enter the wound from the forceps, knives, etc., will not really do any harm, it is as well, in order to avoid unnecessary irritation, to rinse the instruments before using them in a 1-2000 sublimate solution, basins of which, as has already been mentioned, should always be standing by the side of the operator and his assistants. After an instrument has been used it should be rinsed in the sublimate solution before being again employed. A word of caution may be given concerning the manner of handing ligatures and sutures to the surgeon. It is too frequently the custom to seize the ligature by one end, and hand it with the other hanging free. The consequence is that, if the thread be long, its free end is very likely to come into contact with some unpurified object, such as the blanket or an article of clothing, in transit, and sepsis may thus be introduced into the wound. All ligatures and sutures should either be given to the surgeon with the free end coiled up in the palm of the hand, or one end should be taken in each hand, and special care taken to see that the intervening portion does not touch any unpurified object. Similarly, when there is a large wound to be sewn

up, and the surgeon is handed a long suture for the purpose, it is a good plan to keep the slack of the thread as much as possible in the basin of lotion at the side of the field of operation, used for dipping the hands, etc., as otherwise it is often difficult to keep it out of the way of objects that have not been rendered aseptic.

Certain precautions as to **dress** must be taken by the surgeon and his assistants in order to avoid accidental contamination of the wound during the course of an operation. The sleeves should be rolled, pinned or otherwise fastened up well above the elbow, so that they cannot by any chance come into contact with the wound. This is a much better plan than that of wearing "operating sleeves" or cuffs, which is somewhat common. If the latter are worn they should be treated in precisely the same manner as the antiseptic towels (see above); mackintosh sleeves alone should never be worn as they cannot be safely rendered aseptic. Most surgeons also wear some form of operating apron, reaching from above the collar to the ground. The best form is that made of the thin jaconet, used for operation mackintoshes, and it should be well washed over with the strong mixture prior to commencing the operation. As this cannot, however, be made and kept aseptic during the operation with any certainty, and as some part of it is very likely, especially if the surgeon be stout, to come into contact with instruments, or even the field of operation as the surgeon bends over it, it is well to have in addition one of the antiseptic towels mentioned above (or some similar contrivance) pinned to it over the chest and abdomen. Each assistant should take precautions similar to those employed by the surgeon.

Management of Sponges.—The sponges when removed from the jar in which they are kept, should be rinsed in a 1-2000 sublimate solution, and during the course of the operation they should never be washed in ordinary water. When they have become soaked with blood they should first be squeezed as dry as possible, then rinsed and squeezed thoroughly in a cold 1-2000 sublimate solution, and placed in a vessel containing a similar warm solution, which is handed to the surgeon. The surgeon then wrings the sponge dry before he uses it. The nurse should of course disinfect her hands; but, as she is constantly soiling them, she should not be allowed to wring out the sponges and hand them dry to the surgeon; this is an important point which is constantly neglected.

Avoidance of Aerial Infection.—At one time considerable stress was laid upon the chance of wound infection by the air, but we now know that the organisms generally met with in the air are saprophytes, which do not grow in the tissues; in fact, they are non-parasitic organisms. Hence the risk from organisms falling into the wound from the air, and giving rise to trouble, is comparatively slight. At the same time it must be admitted that in a hospital ward, where a case of erysipelas may be present, there would be such a risk, and in hospital practice there must always be a certain degree of danger from this source. In the method we recommend

any aërial organisms which come in contact with the wound, the instruments, etc., are rendered inert by the fact that they fall into strong antiseptic solutions, for even although all the spores may not be destroyed, the non-spore-bearing organisms, such as those of erysipelas, would at once be killed.

Irrigation of the Wound.—With a view of still further effecting this object it is well, as an additional precaution, to douche the wound from time to time with a 1-2000 sublimate solution. No doubt, theoretically, there must be a certain amount of irritation of the raw surfaces as a result of this procedure, but after all it does not make itself manifest in the healing, though it probably might do so were a 1-20 or a 1-40 carbolic acid solution employed for the purpose. In operations upon healthy joints, where a cavity is left which may contain blood and in which non-parasitic organisms might develop, it is very important to keep a stream of weak sublimate (not stronger than 1-4000 watery solution) running over the wound. In ordinary cases, instead of squeezing the 1-2000 solution out of the sponge into the basin, it suffices now and then, during the course of the operation, to squeeze the sponge over the wound, more particularly while the stitches are being inserted. After the wound has been stitched up, judicious pressure will expel all the lotion left in it.

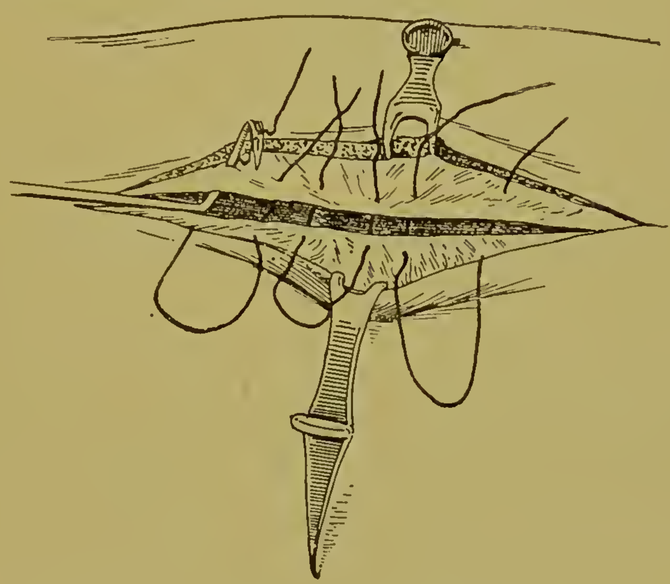

FIG. 51.—DEEP SUTURE FOR APPROXIMATION OF MUSCULAR PLANES. This stitch is merely an applicat on of MacEwen's hernia stitch. The method of passing the thread is shown in the sketch. It may be introduced either by an ordinary surgical needle or, better, by the handled needle shown in the figure. A very simple plan of introducing the suture is to pass the needle unthreaded through the two opposing cut surfaces, pass the thread through the eye and withdraw the needle, carrying one end of the thread with it. This leaves the needle threaded to a suture which traverses both lips of the wound. The threaded needle is now thrust through the edge of the incision from which it last emerged, carried across the wound, made to pierce the opposite side, and the suture unthreaded. The needle is now withdrawn, leaving the loop shown above *in situ*. This is not the method of inserting the stitch illustrated above.

Drainage.—After the operation has been performed with the various precautions mentioned, the bleeding is arrested by one of the methods already described (see p. 128), and suitable stitches are inserted (see p. 153).

At this stage the question of drainage arises. When Lord Lister began his antiseptic work he laid very great stress on the use of drainage, and at one time no doubt one of the results of the free application of carbolic acid to wounds was a very marked exudation of serum, which, if not allowed to escape, distended the wound and sometimes caused considerable trouble in healing. But with the introduction of sublimate solution and the avoidance of carbolic acid in the wound, the conditions underwent a change, and at the present time it is only comparatively seldom that drainage is required.

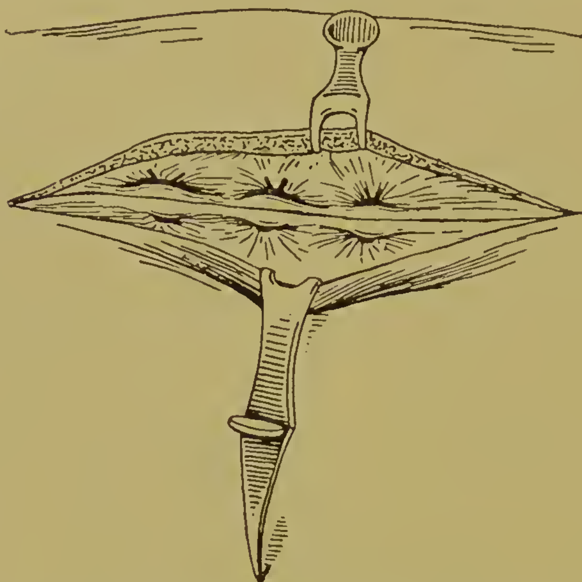

Fig. 52.—Deep Suture for Approximation of Muscular Planes. The three sutures are tied. The sketch shows the thick ridge formed by the approximation of the tissues, which are in contact over a comparatively wide area. The ends of the sutures are cut short, and the skin is afterwards united by a separate continuous suture.

When drainage is not employed, means must be taken to bring the deeper parts of the wound into apposition. To effect this some surgeons introduce stitches, which are left buried in the wound. This may sometimes be necessary where many muscular planes are divided, as, for instance, after laparotomy (the most suitable form of stitch for which is shown in Figs. 51 and 52), exposure of the kidney, etc., but as a general rule we consider that sponge pressure applied outside the wound is sufficient. By one or other method, however, any cavity that is left can generally be obliterated, and it is only in certain cases of incised wounds made by the surgeon that this is impossible ; in them, drainage tubes are required.

Cases calling for Drainage.—The following are the chief conditions in which drainage seems desirable :

(1) *In amputation wounds.*—After amputation it would not do to keep the flaps firmly pressed together for fear of interfering with their blood supply, while it would be equally hurtful to allow blood to distend them and possibly lead to gangrene. Therefore it seems advisable, in all cases of amputation, to introduce a drainage tube.

(2) *Where a cavity is left.*—For example, after excision of one half of the thyroid gland a cavity is left into which bleeding is very apt to occur, for pressure cannot be applied satisfactorily without interfering with the trachea; in these and similar cases the temporary use of a drainage tube is advisable.

(3) *Where the patient is spare.*—In these subjects the skin is thin and there is only a small amount of subcutaneous fat, so that pressure could not be employed without risk of sloughing.

(4) *In very fat people.*—Wounds in very stout people seem to fill with oil, and this apparently interferes with the proper healing of the wound; in these cases also it is well to employ drainage.

(5) *Where there is a risk of sepsis.*—Drainage should always be employed where a sinus or ulcer is present at the seat of operation, lest the attempt to disinfect them prove unsuccessful.

When a drainage tube is introduced it need not extend the whole length of the wound so long as it passes into the deeper parts of it, and it is well, in order to avoid the risk of displacement of the tube, to stitch the outer end to the edges of the skin after cutting the tube flush with the surface. Drainage tubes need not be left in a wound longer than three or four days unless sepsis occurs. If it be desired to leave a particularly small scar, a few strands of horse-hair or catgut (preferably horse-hair), or a wisp of cyanide gauze, will suffice to form a fine capillary drain.

Dressings.—After having completed the operation, stitched up the wound, and arranged for drainage if necessary, the next point is the application of the dressing. The blood should be washed away from the neighbourhood of the wound with the 1-2000 sublimate solution, and then a suitable antiseptic dressing applied. It is as well, during the process of washing away the blood from about the wound, etc., to protect the wound from infection by means of a piece of cyanide gauze soaking in 1-2000 sublimate solution; this is removed when the dressing is ready to be applied. At the present time the tendency is towards the use of dry dressings, which possess two great advantages. In the first place, the blood dries quickly in them and does not therefore form a suitable soil for the development of organisms, and consequently, if the dressings are not quite aseptic, or the skin be not completely disinfected, the organisms may be unable to grow and reach the wound. In the second place, the dried up blood-stained dressings adhere to the skin and form a sort of splint, which keeps the edges of the wound absolutely at rest.

Lister's Cyanide Gauze.—The most universally applicable and most satisfactory dressing yet introduced is the latest dressing proposed by Lord Lister, viz., gauze impregnated with the double cyanide of mercury and zinc. Certain precautions must be taken in using this dressing. As supplied from the manufacturer, it contains an amount of free corrosive sublimate which, if brought in contact with the skin, might, in delicate skins at any rate, lead to blistering. Hence the free sublimate must be

washed out before the dressing is used. A great advantage of this is that it gets rid of an objection which applies to all dry dressings except those disinfected by heat, namely, that as it comes from the makers the dressing may contain dust and organisms, some of them possibly pathogenic; it is well therefore to disinfect the dressings before use by the application of some antiseptic solution. With the object therefore both of dissolving out the free sublimate and of providing an aseptic dressing, it is well to keep the cyanide gauze in a jar of 1-40 or 1-60 carbolic acid, or, where it has to be used for children (who are very susceptible to the action of carbolic acid), in a 1-4000 or 1-6000 sublimate solution. The dressing kept in this solution is ready for use at any time, and all that is necessary is to wring it out before applying it to the wound. As no impermeable layer, such as mackintosh, is applied outside it, the gauze quickly dries, and in a few hours a perfectly dry dressing is formed. In applying an antiseptic dressing large quantities should be used; there should be no stint whatever, and a wide area of skin all around the wound should be covered. Besides being extensive in area, the dressing should also be of considerable thickness, some 12 to 20 folds of gauze being employed.

Pressure.—Before the dressings are put on, the superfluous fluid is squeezed out of the wound and then, after applying the first few folds of the gauze, it is well to place clean sponges wrung out of the antiseptic solution over the area of the wound, so as to approximate the deeper parts and prevent the formation of a cavity. Outside the sponges more gauze is applied, and outside this again a mass of salicylic wool to increase the thickness of the dressing. Salicylic wool, although said to be absorbent, does not absorb at all well, and the object in employing it is not so much to furnish an additional antiseptic layer, though that is an important point, as to provide a material which, while it permits evaporation, at the same time leads to a diffusion of blood and serum over a considerable area of the cyanide dressings. As a matter of fact, however, the discharge from the wound is usually extremely slight where sponges are employed, and seldom reaches the wool at all. Bandages are applied outside the salicylic wool, specially firm pressure being brought to bear over the sponges; and in certain cases, such as operations for hernia, or on the neck, etc., where movements of the thigh or of the head are inevitable, it is well to apply a piece of white elastic webbing round the edges of the dressing so as to prevent them from becoming separated from the skin by the movements of the patient (see Figs. 53 and 54).

When to change Dressings.—A dressing of this kind is usually left undisturbed for about ten days, unless there be some reason for changing it, such as discomfort, fever, the presence of a drainage tube, or any suspicion of sepsis. It is a mistake to change a dressing soon after the operation unless it be really necessary, because the dressing adheres to the skin, and, in pulling it off, the union of the deeper parts may be disturbed,

and bleeding may even occur into them. The following are the principal cases in which an early change of dressing is called for:

(1) In some cases, the dressings as they dry become hard and uncomfortable, and in sensitive patients therefore it is often advisable to change them at the end of three or four days; the second dressing never becomes so hard and uncomfortable as the first.

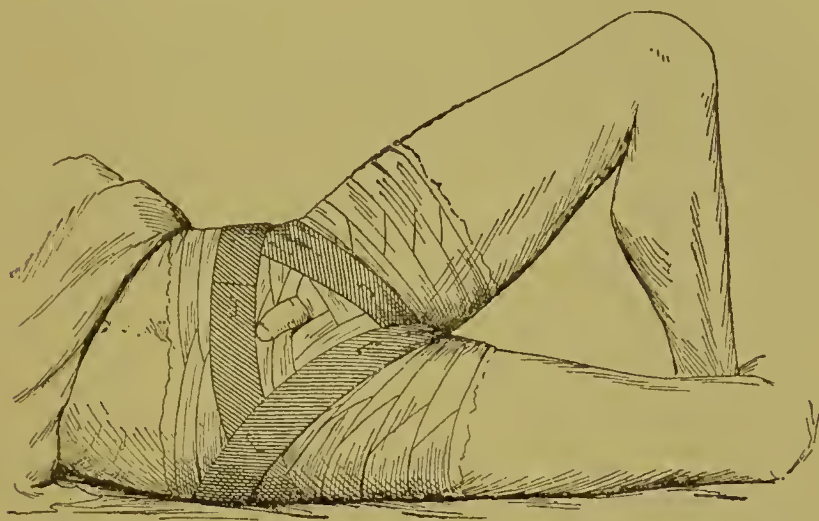

FIG. 53.—METHOD OF EMPLOYING ELASTIC PRESSURE TO KEEP DRESSINGS IN POSITION. The sketch shows a front view of the dressings we usually apply after hernia operations, and illustrates the method of applying the elastic webbing; this is stretched fairly tight, and is still further prevented from slipping by the safety pins shown in the figure.

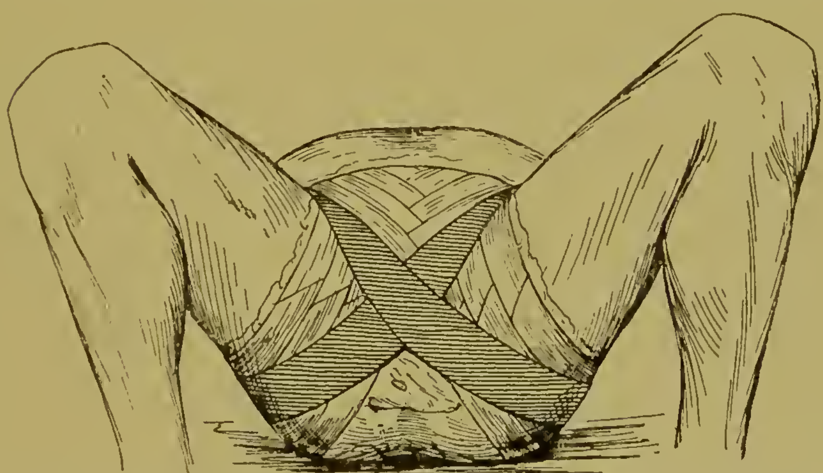

FIG. 54.—METHOD OF EMPLOYING ELASTIC PRESSURE TO KEEP DRESSINGS IN POSITION. This is a sketch of the same dressing as in Fig. 53, but seen from below. It shows the manner in which the webbing crosses in the perineum.

(2) When the amount of discharge from the wound is excessive. The old rule that dressings required changing very soon after discharge showed itself through them is not now applicable; as a matter of fact, it is not uncommon with the dressings just described, where no mackintosh is applied on the outside, for a little blood to

appear at the edge within a few hours after the operation; but this very quickly dries up and does not form a cultivating medium for the growth of the bacteria, because the double cyanide salt is a powerful inhibitory agent against their growth, and, being only slightly soluble, is not washed out by the first blood which passes through the dressing. All that is necessary is to sprinkle some iodoform over the soiled portion, to apply fresh salicylic wool outside this, and to secure it by another bandage. At the same time, if the discharge be very free at first, it may be desirable to change the dressing after 24 or 48 hours.

(3) When a drainage tube has been inserted, the dressings must be changed at the end of four or five days in order to remove it; if the wound be large, the discharge through the tube may be sufficiently copious to necessitate a change of dressing at the end of 24 or 48 hours.

(4) If after the operation the temperature rise and remain over 100° F.. for more than 24 hours, or if there be much pain, the dressing must be removed to see if anything is wrong with the wound.

How to change them.—When the dressings are changed at the end of about ten days, the wound is usually soundly healed; the stitches are then taken out, and a small piece of gauze or salicylic wool is fixed over the line of incision for a few days by means of collodion. In changing dressings it is well to employ a 1-2000 sublimate solution to wash the wound, except in operations in the axilla, the perineum, or about the pubes, etc., where, on account of the proximity of hairy parts, it is advisable to wash the skin around the wound thoroughly with a 1-20 carbolic lotion. The region of the wound should be surrounded by towels wrung out of the antiseptic solution, so that, should the patient move, the blankets do not come into contact with the wound, the instruments, or the surgeon's hands. The latter are disinfected in a 1-20 carbolic acid lotion, and subsequently in the 1-2000 sublimate solution. Salicylic wool is a very good material with which to wash the part, and in doing this it is not necessary to rub the wound. If the latter has not quite healed, or if, on account of tension upon the edges, it seems advisable to leave any of the stitches in place for some time longer, a dressing similar to that put on immediately after operation (see p. 169) may be re-applied, the only difference being that the sponges need not be again employed. In breast cases, for instance, where a large amount of skin has been taken away, it is often advisable to change the first dressing before the end of the first week, in order to remove some of the stitches and clean the axilla; the remaining stitches may then be left for another week, when they can be removed.

After-progress of the Wound.—In operations conducted with all the precautions recommended above, it will be found that neither local nor constitutional disturbance follows. In the case of a very severe operation, the temperature is at first sub-normal, the patient suffers from a

certain amount of shock for some hours, and this is followed, to an extent closely corresponding to the degree of shock, by a certain amount of reaction, so that next day the temperature may be up to 100°, or even to 101° F. At the same time, however, the pain complained of immediately after the operation subsides, and there is no fresh development of it, as would be the case were the temperature due to sepsis. In the course of another twelve to twenty-four hours the temperature falls rapidly to normal.

Treatment without Antiseptics.—The other plan, to which we have already referred (see p. 161), in which attempts are made to keep wounds aseptic without the use of antiseptic lotions and dressings, is theoretically good, but practically it does not yield the results which are obtained by the method just described. It consists in the entire avoidance of the use of antiseptics during the actual performance of the operation, and in the after-treatment of the wound. The skin is purified, and the hands of the assistant and the operator are disinfected very much in the manner already described (see p. 161). The instruments are boiled, but are not afterwards immersed in antiseptics, and there is no antiseptic solution at hand to douche the wound; the swabs consist of pieces of wool disinfected by heat and used dry, and the towels placed around the operation area are also dry, and have been previously disinfected by heat. There is therefore no possibility of correcting any accident that may happen during the operation, such as dust falling on the towels, or the unobserved contact of the hand with any object that has not been disinfected. The dressings consist for the most part of simple absorbent unmedicated wool, which is disinfected by heat, the box or bag in which the wool is disinfected being only opened at the side of the patient by the surgeon himself; it is obvious that the greatest care is required in handling these if accidental contamination is to be avoided. In the "antiseptic" or Listerian plan, which is the one we have recommended, these accidents, if they do occur, may be automatically remedied, because everything is being frequently soaked in antiseptic solutions. In the so-called "aseptic" plan there is no corrective for these accidents at all, and, consequently, experience shows that the results are not equal to those of the other method.

No doubt, theoretically, it ought to be possible to carry out this aseptic plan, and if it were found in practice that the use of antiseptics gave rise to great irritation in wounds, the employment of a cumbrous and troublesome method, such as the so-called "aseptic" one, would be justified. As a matter of fact, however, the irritation of wounds from such antiseptics as we have recommended is inappreciable, and there is not the least reason for the introduction of this troublesome method, more particularly as the results obtained by it are not so good. The method can only be carried out by a skilled and experienced bacteriologist, with all the resources of a large and well-equipped hospital at his

command. In ordinary private practice, not only is it almost impossible to carry it out in all its details, but, as a single error may invalidate the whole proceeding, and as no corrective is possible, the plan may be positively harmful.

Causes of Failure to secure Healing by First Intention.— Where all the steps of the antiseptic method have been rigidly adhered to, there is very seldom failure to obtain healing by first intention. When it does not occur, it is, in the majority of cases, because some error has been committed in the management of the case, which has led to the occurrence of sepsis. Sometimes, however, union may fail, in part at any rate, notwithstanding the fact that the wound remains aseptic. Perhaps the most common cause of this is the *accumulation of serum* in the deeper parts of the wound; these are cases in which a drainage tube should have been employed. If accumulation does take place, it is better to evacuate the serum than to wait in the hope that it will be absorbed; doubtless this sometimes occurs, but in the majority of cases it will find its way out along the line of incision. Wherever, therefore, it is found at the first dressing that there is a collection of fluid in the wound, time is really saved by opening up the incision with a pair of sinus forceps, letting out the fluid and introducing a small drainage tube, which should be left in for two or three days. The fluid will be found to be merely serum or altered blood, and when a drainage tube is introduced and pressure applied outside, the wound closes very quickly.

Mention has already been made of the importance of putting in a sufficient number of stitches to prevent gaping of a wound, and also of not tying them so tightly that they will cut through the skin. If a sufficient number of stitches has not been employed, the tension on any individual stitch may be so great that it will cut its way through the skin and allow a portion of the wound to gape. *Movement* of the part also interferes sometimes with primary union, and in other instances the cause of non-union may be that the knife has been held obliquely in making the skin incision; the bevelled edge of skin thus left on one side often dies. In most cases, however, when union fails, it is owing to the presence of *sepsis*, and if suppuration occur in a wound made by the surgeon through unbroken skin, the surgeon himself is entirely to blame for its occurrence. Whether it be that he has used impure materials for his ligatures or stitches, or whether, as is commonly the case, he or his assistants have introduced the organisms with their hands, he is equally responsible. This fact cannot be too widely appreciated.

Errors which may be made in carrying out the antiseptic treatment of wounds have already been described, but it is quite impossible to point out all the extraordinary mistakes which are daily committed. All that can be said with regard to them is that, unless the surgeon constantly bears in mind the fact that nothing that has not been made aseptic must come in contact either with the wound, the instruments, or the hands that

are introduced into the wound, he will be sure eventually to go wrong. A preliminary bacteriological training is of incalculable advantage, for with it the manipulations necessary to secure asepsis become automatic, and the surgeon is thus enabled to concentrate his undivided attention upon the operation.

Treatment where Sepsis occurs.—When, in spite of all efforts to prevent it, sepsis occurs, its onset is indicated by pain and throbbing in the wound. The reactionary temperature commonly met with after severe aseptic operations, instead of falling in from 24 to 36 hours, continues to rise, and all the symptoms of pyrexia set in. Whenever this febrile condition is established, the wound should be at once examined, and if red, tender, or swollen, it should be opened up, at any rate at the most dependent spot, and proper drainage provided. As a rule it is not advisable to wash out a wound in this condition, although it is done by many surgeons. Washing out a septic wound with antiseptics will not arrest the infection, and the only effect it can produce is to irritate and damage the inflamed tissues, and possibly to precipitate, or at any rate to facilitate, the entrance of micro-organisms into the system. Provided there be a free exit for pus, it is best not to wash or squeeze out or in any way irritate the wound. The only exception to this rule is in the case of large cavities, where there is reason to believe that the symptoms are mainly due to septic intoxication, that is to say, absorption of poisonous chemical products and not true general bacterial infection. Under such circumstances it is well to wash away the septic fluid in the wound with sterilised water or with some very weak antiseptic solution, such as 1-4000 or 6000 sublimate solution, not with the view of killing bacteria, but of removing the poisonous chemical products which are being absorbed, and are producing the symptoms. It is well to go on with the antiseptic dressings already described (see p. 169), but they should now be changed daily.

Where no general infection has occurred, or is about to take place, the temperature falls, and the other general and local conditions improve within a few hours after a free exit has been provided for the discharge. In the course of a few days suppuration ceases and the discharge becomes serous, and if everything goes well, the drainage tube may be left out in from 10 to 14 days. Where, on the other hand, the temperature keeps up and the other symptoms continue, the suspicion is aroused either that there is some recess in the wound from which the discharge is not properly escaping, or that some general infection is occurring. In either case the wound must be thoroughly and completely opened up and cleansed, all recesses must be freely exposed, and, especially where there is not sufficient retention of discharge to account for the general symptoms, the wound should be thoroughly sponged out with undiluted carbolic acid. In some cases the surgeon may even venture to scrape away the granulation tissue with a sharp spoon, but in doing this there is always a certain risk of forcing organisms into the circulation. If it be done, one of Barker's

flushing spoons (see Fig. 55) should be employed, the fluid used for irrigation being a 1-4000 sublimate solution. After the wound has been thoroughly sponged out with liquefied carbolic acid, it should be stuffed with cyanide gauze freely sprinkled with iodoform, and made to heal by granulation from the bottom, the stuffing being renewed once or even twice daily if the suppuration persist. If, as the result of this procedure, the temperature fall and the general disturbance subside, it may be possible in three or four days to discontinue the stuffing, and, after introducing a drainage tube, to stitch up the edges of the wound again.

FIG. 55.—BARKER'S FLUSHING SPOON. This is a hollow sharp spoon which is connected with a reservoir of fluid by means of india-rubber tubing attached to the handle (the attachment is shown at the right-hand end of the figure). The passage of the fluid is regulated by the sliding valve seen on the upper surface.

When the occurrence of rigors, and sudden elevations of temperature, lead one to suspect pyæmia, it is important in opening up the wound to look carefully for any thrombosed veins, and should any be found, the main vein above the thrombosed area should be ligatured, and a portion excised in order to cut off the local source of infection from the general circulation. When the constitutional symptoms persist in spite of this energetic local treatment, nothing remains to be done but to treat the patient on general principles, the strength being supported by stimulants, and a diet as nutritious as he is able to digest being administered. Where the temperature is excessively high, it may be kept down by quinine or other febrifuges, or by the employment of cold sponging or cold baths; the state of the excretions should be carefully attended to. These matters will be referred to more in detail when we come to speak of the treatment of Pyæmia (see Chap. X.). The only thing of any service in the local treatment, when the general symptoms persist, is to continue stuffing the wound with gauze impregnated with iodoform; sometimes when there is diffuse cellulitis in the neighbourhood, constant irrigation may be employed, to wash away the septic material as soon as it is formed. The methods of irrigating wounds have already been described under the head of Diffuse Cellulitis (see p. 30).

Treatment of Wounds where the Edges are not brought together.—We have still to consider another class of wounds, made by the surgeon through unbroken skin, those, namely, where it is quite impossible, in spite of any freeing of the edges, to bring the margins of the skin together, and where, therefore, an open wound must be left. Here also it is important that organisms should be excluded, and if this be successfully accomplished, and steps taken to keep the part absolutely at rest and to prevent irritation by the dressings, the space between the edges fills up with blood, and healing by blood-clot will occur. To obtain this

result, similar methods and dressings should be employed to those used where the edges are brought together; but, in order to protect the blood-clot from the irritation of the dressings, a piece of Lister's oiled silk protective, somewhat larger than the wound, should be interposed; the protective is soaked in the sublimate solution for some time previous to application, and outside it a large gauze and wool dressing is applied. What most commonly happens where the wound is large is that healing by blood-clot occurs to a considerable extent, and then a small part in the centre undergoes a certain amount of granulation before complete cicatrization takes place.

Thiersch's Skin-grafting in Fresh Wounds.—Healing by blood-clot is, however, a slow process, and there is always a risk of accidental contamination of the wound; therefore, a quicker method of obtaining healing, namely, Thiersch's skin-grafting, is often employed. By its adoption immediately after the infliction of the wound, a good result will be obtained in most cases, and healing will occur almost as rapidly as in union by first intention, while the contraction which follows granulation will, to a great extent be avoided. Skin-grafting should be employed, if possible, at the end of the operation, as soon as the bleeding has been arrested, and, with the exception that in these cases there is no granulating wound to scrape, the whole process is the same as that already described on p. 50. Where the operation has been very extensive, and the patient is very collapsed, it may be advisable to defer the skin-grafting for a short time; in these cases, after about ten days, the blood-clot is scraped from the surface of the wound, and, when the oozing has been arrested, the skin-grafts are applied in the usual manner. At first sight, it might be supposed that the skin-grafts would not adhere well to non-granulating tissues, but as a matter of fact they do, and much may be done to improve the condition of affairs by immediate skin-grafting.

Plastic Operations.—Where the cutaneous loss is not excessive, and the skin in the neighbourhood is fairly lax, the interval between the edges of the wound may be made good by means of a plastic operation. By a plastic operation is meant one performed with the view of covering in some defect in the skin, mucous membrane, etc., whether congenital or acquired. In the present instance we have only to do with the covering in of defects left after an operation in which the edges of the wound cannot be brought together. The plastic operations in connection with congenital defects will be dealt with in their proper place.

The simplest form of defect is an **oval wound**, and here the steps necessary to bring the edges into apposition are generally very simple. All that is necessary in most cases is to undermine the skin around the wound for a sufficient distance to allow the elasticity of the skin sufficient play. A very extensive oval defect may be repaired in this manner; in removal of the breast, for example, an interval of twelve inches or more may be closed by undermining the skin.

The plan of *undermining the skin* has already been mentioned (see p. 157), but we may here give fuller details of the method. The best way is to proceed as follows. In small wounds, the knife is carried between the superficial fat and the deep fascia; in extensive ones, it should be swept between the deep fascia and the muscle, and by this means the skin and fascia are raised from the deeper parts for a considerable distance around the wound. The undermining should be most extensive opposite the shortest diameter of the oval, and should be carried on until the edges of the wound can easily be brought into contact by pulling upon them. In raising these flaps, great care must be taken to direct the edge of the knife towards the deeper parts and not towards the skin; failure to observe this precaution is apt to result in scoring of the flap, and, as the blood-vessels which supply the skin ramify in the subcutaneous fat, the blood supply to the edges of the wound might be cut off and sloughing might ensue. The freeing of the edges of the wound by undermining must be carried out sufficiently widely to allow them to come together without endangering the circulation in the flaps. If it has not been done sufficiently freely, the flaps will become white on putting in the stitches, and after waiting a little the circulation will not be restored; it will, therefore, be necessary in such a case to carry the undermining further, when the flaps may be brought together without being permanently blanched. If at first there be a little whiteness in the immediate vicinity of the stitch, it will disappear in a few minutes when the tension is not too great. Deep stitches and sometimes button stitches should be used so as to relax the edges in order that there may be no tension upon the actual line of union.

Where the wounds are angular, or quadrilateral, or irregular in shape, they require for their closure one of the plastic operations proper. The

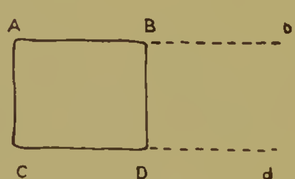

FIG. 56.

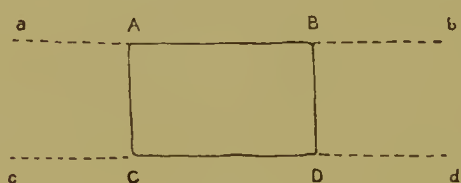

FIG. 57.

FIG. 56.—PLASTIC OPERATIONS. *How to fill up a quadrilateral defect of moderate size.* By carrying incisions horizontally outwards from *B* to *b* and from *D* to *d*, a flap *B D d b*, can be dissected up and pulled inwards so that the edge *B D* comes into contact with and is sutured to *A C*. The incisions *B b* and *D d* should be longer in proportion to *A B* and *C D* than are here represented.

FIG. 57.—PLASTIC OPERATIONS. *How to fill up a quadrilateral defect of large size.* Here, by a similar procedure to that shown in Fig. 56, a flap is dissected up on each side of the defect. The two flaps are then pulled inwards to the middle line, and *A C* is sutured to *B D*.

simplest of these is perhaps a small **quadrilateral** defect; this is very easily filled up by making incisions which extend the corresponding sides of the parallelogram straight into the healthy skin on one side, that is to say, in Fig. 56, the side *AB* is extended to *b* and *CD* to *d*. The flap *BDdb*, which ought generally to be about double the length of the side

AB, is then dissected up along with the subcutaneous tissue. When dissected up in this way, the elasticity of the skin allows the flap to be stretched with comparatively slight tension, so that the point *B* may be stitched to the point *A*, and the point *D* to the point *C*.

Where the quadrilateral defect is larger, it can be closed by making similar incisions on the opposite side also, that is to say, in Fig. 57, by extending the side *AB* both to *b* and to *a*, and similarly *CD* to both *d* and *c*. Two flaps, *ACca* and *BDdb*, are thus marked out, one on each side, and when they are dissected up they can generally be made to meet in the middle of the defect and can be stitched together.

Where the defect is **triangular**, say an equilateral triangle, and the raw area is small, it may suffice to make an incision which, in Fig. 58, extends

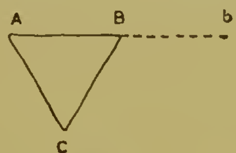

FIG. 58.

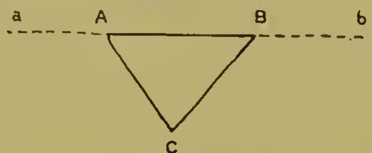

FIG. 59.

FIG. 58.—PLASTIC OPERATIONS. *How to fill up a triangular defect of moderate size.* By carrying an incision from *B* to *b*, a flap *C B b* can be raised, so as to allow the side *C B* to be pulled towards and stitched to the side *C A*. The incision *B b* should be nearly double the length of *A B*.

FIG. 59.—PLASTIC OPERATIONS. *How to fill up a triangular gap of large size.* The dotted lines show the incisions made to allow two flaps to be raised. When this is done, *A C* and *B C* are approximated and stitched together.

the side *AB* to one side only, the extension being about double the length of the side *AB*. The triangular flap thus marked out is dissected up along with the fat, when the point *B* can generally be stitched to the point *A*. If, however, the defect be large, the sides may be made to meet by forming a second similar flap on the other side, that is to say, in Fig. 59, by extending the line *AB* on the one side in the direction of *A*, and on the other side in the direction of *B*. These two flaps will then meet in the middle line and can be sewn together.

In many cases, however, especially where the triangular space is large, the incisions for the flaps should be *curved*, and, in the case of irregular

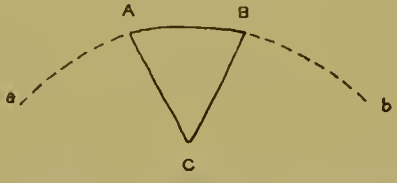

FIG. 60.—PLASTIC OPERATIONS. *To fill in a triangular defect by means of curved incisions.* By carrying a curved incision from *B* outwards to *b*, and one from *A* to *a*, the flaps thus formed can, after they have been dissected up, be made to slide inwards so as to approximate *A C* and *C B* with much greater ease than if straight incisions had been used.

defects, the great secret of successful plastic operations is to use curved incisions. Much better results will be obtained by the use of curved incisions than by straight ones. When it is necessary to remove the lower lip, this is usually done by taking out a V-shaped piece, the apex of the V being

towards the chin. To fill the gap a large curved incision should be made, beginning at the angle of the mouth, running down over the jaw on to the neck, and curving inwards towards the upper part of the larynx; where the whole lip is removed a similar curved incision is made on each side. The incision goes through the whole thickness of the cheek; when it passes on to the neck, the skin and superficial fascia alone are dissected up. When the flaps have been raised sufficiently, the curved incisions allow them to slide inwards, so that the two sides of the triangular defect meet in a vertical line, and may be stitched together; a few points of suture are then put in along the curved lines of incision (see Fig. 60).

We need not here go into detail as to the covering in of irregular defects, or of those in special situations. They will be treated of later on as occasion arises. The great principle to which we wish to call attention is that, where the surgeon has to do with large defects of skin, curved incisions will enable him to close the defect with much greater ease and less extensive dissection than if straight incisions alone were employed.

Use of Granulating Flaps.—Where there are very large defects, and where the flaps to be turned in would be very long and have a comparatively narrow base, in other words, where the blood supply would necessarily be imperfect, it has been recommended that the flap should be dissected up but left attached at each end, and that both it and the wound should be allowed to granulate before the actual transplantation of the flap takes place. The reason for this suggestion is that, by dissecting up the flap but leaving it attached at both ends, it is more likely to retain its vitality, while new blood-vessels and a more perfect blood supply are developed during the process of granulation.

In this plan the flaps are usually made more or less quadrilateral, and their two ends are not detached. After disinfection of the skin, lateral incisions are made down to the deep fascia, and then the flap is undermined throughout its whole extent, so that the finger can readily be passed under it in all directions. A piece of protective, dipped in a 1-2000 sublimate solution, is then inserted between the under surface of the flap and the deeper structures, and this is kept in place for from ten to fourteen days. At the end of this time the new vascular supply will have developed, and one end of the flap is divided, and the latter turned in so as to cover the defect. This method certainly does overcome great difficulties with regard to the nutrition of the flaps, but cases in which such elaborate measures are necessary are usually more successfully treated by Thiersch's skin-grafting.

Occurrence of Sepsis in Open Wounds.—Should these wounds become septic in consequence of some error committed during the operation or the subsequent treatment, the results as regards the patient are not usually of a very serious character, unless the wound communicates with a cavity in the bone or with the interior of a joint, etc.; the wound being widely open, the septic material readily flows away into the dressing, and only

a small amount of the poisonous substances remains to be absorbed. Nevertheless, if the wound be at all large, the temperature rises at first, and a varying degree of traumatic fever occurs, while the edges of the wound become swollen, red and painful, and in the course of two or three days its surface becomes covered with a layer of granulation tissue.

Treatment.—As soon as it is thought, from the rise of temperature and other symptoms, that sepsis has occurred, the dressings should be removed, and if then it be evident that the antiseptic treatment has not been altogether successful, the surface of the wound should be thoroughly cleansed and all the adhering portions of blood-clot removed. In most cases where the symptoms are not severe, the cyanide dressings may be continued, but they will need to be changed daily, and the surface of the wound will require to be washed with a 1-2000 sublimate solution. If there be much inflammation, it will be well to put a layer of mackintosh outside the wet cyanide dressings, so as to keep them moist, and then the dressing should be changed night and morning. Carbolic acid is not a good lotion to apply to the surface of these wounds, especially in the early period, because it seriously injures the vitality of the granulation cells, and thus interferes with their power of destroying the virulent organisms on the surface. Moreover, granulating wounds treated with carbolic acid absorb much more readily than when treated in other ways.

Where the discharges are very foul, *iodoform* is often useful, for, although as an antiseptic the drug is of very little value and is not at all to be recommended for a freshly made wound where the surgeon presumably takes all precautions necessary to prevent the entrance of micro-organisms, it does become more or less of an antiseptic when applied to a putrefying sore. It then seems to break up the toxic products of the bacteria, and in doing so becomes decomposed itself and free iodine is liberated. Hence, in septic wounds, the drug by destroying the products of the bacteria takes away their weapons so to speak, while at the same time the iodine liberated inhibits the growth of the bacteria, or may even actually destroy them. Whenever iodoform is used, it should be disinfected beforehand by immersing it in a 1-20 carbolic acid solution for several days, straining it through muslin, and then drying it under cover.

When in these septic wounds granulation is complete and the febrile condition has passed off, it is well to substitute mild antiseptic dressings, such as antiseptic ointments, or the boracic lint and protective dressing used in ulcers (see p. 47). Of ointments, the ung. boracis is undoubtedly the best; at first it should be of the full pharmacopœial strength; but after four or five days, when healing is commencing, half or even quarter strength should be substituted, because the full-strength ointment seems to be too irritating for the young epithelial cells, and prevents the cicatrization of the wound. If the wound be large, skin-grafting may be employed after about a fortnight, and in that case the process is exactly the same as in grafting an ulcer (see p. 50).

WOUNDS THAT CANNOT BE KEPT ASEPTIC.

The second great division of wounds made by the surgeon are those which not only involve the skin, but communicate with one of the mucous canals or with a septic cavity which cannot be effectually disinfected. It is impossible, for example, to exclude bacteria from a wound in the mouth, seeing that they are everywhere present in the fluids on the surface of the mucous membrane. The problem, therefore, is not how to exclude bacteria from these wounds, but how to minimise their deleterious action.

Wounds of Mucous Membranes.—In the first place, it is important that, during the performance of the operation, the manipulations should be gentle, and pinching or rough treatment of the tissues should be avoided; in other words, their vitality must be interfered with as little as possible. In wounds involving the mucous membranes, union by first intention should not be aimed at, except in rare cases such as operations for cleft palate, etc. Where union by first intention is desired, the bleeding must be thoroughly arrested, care must be taken that no foreign material is left between the edges of the wound, and that the whole of the cut surface, and not merely the edge of the mucous membrane, is in accurate and close apposition. In wounds of mucous membranes healing by blood-clot will not take place. The use of silk for stitches in these cases is out of the question, because it is absorbent and will retain decomposing material. The best material is either silkworm gut, or, where a finer stitch is wanted, horse-hair. No dressing applied to the wound is likely to be of any real service, but it is well, instead, to wash the surface of the mucous membrane frequently with weak antiseptic solutions, such as Condy's fluid (one or two grains to the ounce), or sanitas (about a tea-spoonful to the tumbler of water). The more irritating antiseptics, such as carbolic acid, should not be employed.

Where the edges of the wound are not brought together, and where, therefore, healing by granulation must take place, it is of great importance to avoid septic decomposition on the surface of the wound during the first two or three days; at the end of that time, there is usually such a marked invasion of cells in the wound, that bacteria find considerable difficulty in entering. Almost the only bacteria that are able to penetrate at a later period than this are streptococci or such organisms as the diphtheritic bacteria. For keeping these sores aseptic for the first few days, Lord Lister used to employ a solution of **chloride of zinc**, of a strength of forty grains to the ounce, thoroughly sponged over the surface of the wound after the bleeding had been arrested. He regarded it as, so to speak, pickling the surface of the wound for a day or two after it had been made, and it is certainly a fact, that, after a thorough application of chloride of zinc to a cut surface exposed to the elements of putrefaction, decomposition does not occur so early as where the wound is left to nature, and therefore this method is one which

may be strongly recommended. It is especially in these cases that **iodoform** is of value, and it is well, after having sponged the cut surface with the chloride of zinc solution, to powder it with iodoform crystals. Care must, however, be taken in cases of wounds in the mouth, not to be too lavish in the use of iodoform, because otherwise a considerable quantity is swallowed, and symptoms of iodoform poisoning may appear.

As soon as the wound is granulating, mild antiseptic washes are all that is necessary in most cases, the best being weak sanitas (about a tea-spoonful to a tumbler of water), or permanganate of potash (one or two grains to the ounce). If the granulations become prominent, the occasional application of solid nitrate of silver or sulphate of copper will keep them down (see p. 58).

In cases where the wound involves both skin and mucous membrane, as, for example, in wounds of the cheek, the skin wound should be stitched up with interrupted sutures of silkworm gut, but the wound on the mucous surface should be left open, and should be painted over with chloride of zinc solution, and powdered with iodoform. A piece of boracic lint or gauze wet with a 1-2000 sublimate solution should be laid over the line of the incision in the skin for a few hours, till the bleeding has quite ceased, and then half strength boracic ointment and boracic lint may be substituted. Where there is a pocket in the cellular tissue communicating with the mucous surface, as, for example, where the wound involves the neck and throat, a large drainage tube must be inserted at the lowest point of the wound, so as to prevent accumulation. After three or four days, the tube should be taken out, and replaced by one of smaller calibre. This should be washed in a 1-20 carbolic acid solution, and subsequently in a 1-2000 sublimate solution, every time the external dressing is changed. The ointment should in these cases be changed night and morning. It is usually about the third week before the use of the drainage tube can be given up.

Quite recently an **antistreptococcic serum** has been introduced for use in cases of streptococcic infection. The entrance of streptococci is the most serious and most common form of infection in operations on mucous membranes, especially about the mouth, and this serum seems likely to prove of great value when used as a prophylactic measure before the operation.[1] The object of the preliminary injection of this serum is to protect the body for a time, if possible, against streptococcic invasion, so that the healing of the wound is undisturbed by the action of these organisms; 20 c.cm of this serum should be injected two days before, and 10 c.cm on the morning of the operation. If there be not time for this, the injection of 20 c.cm the night before, and a similar quantity on the morning of the operation, must suffice. A special syringe, which can be disinfected by boiling, must be used. The best place for the injection is in the flanks or the loins; the skin should be thoroughly purified in the first place with strong mixture, and the syringe and needles should be boiled immediately before use.

[1] See *Practitioner*, April, 1897.

The question of the value of this remedy is still *sub judice*, and, as there are probably several forms of pathogenic streptococci, it is well not to place too much reliance on it in any given case. At the same time, it seems distinctly of value in certain cases, if used as a prophylactic.

INCISED WOUNDS INFLICTED ACCIDENTALLY.

Another occasion on which a wound may come under the notice of the surgeon is where it has not been made by him, but has been inflicted some hours before it comes under his care. Here, the problem is not so much to prevent the entrance of bacteria into the wound, as to destroy any that may have already entered. The degree of the contamination of such a wound depends on the part of the body injured, and on the weapon with which the wound has been inflicted.

In wounds of the scalp there is certain to be very considerable infection from hairs or scurf carried into the wound at the time it is made; and as suppuration in scalp wounds is often very serious, both from the result of the burrowing of pus under the scalp, and also from the proximity of the large veins in the diploë of the skull and the meninges, it is very important that these wounds should be thoroughly disinfected. In cases also where earth or grease has been extensively ground into the wound, great pains must be taken in the disinfection, more especially where bones are injured, as in compound fractures, wounds of joints, etc. These will be referred to in their proper place. Wounds of the face, or of parts not covered by clothes or hair, are not so likely to be seriously infected if the wounds be incised; of course, if they be contused or lacerated, the blunt instrument which inflicted them may have carried in a quantity of dirt, and here, in addition, the edges of the wound are usually bruised and of imperfect vitality.

Treatment.—Where the contamination is but trifling, it may suffice to wash out and sponge the wound well with a 1-20 carbolic acid solution, but in the case of scalp wounds or those in which earth or dirt is obviously present, the treatment must be much more thorough. As a matter of fact, no attempt should be made to obtain healing by first intention over the whole area of the wound, so that the increased temporary irritation of the tissues by the strong antiseptics used for thorough disinfection is not a matter of any consequence. In badly soiled cases, and more especially in compound fractures, it is best to give the patient an anæsthetic, and then to sponge the whole wound out thoroughly with undiluted carbolic acid, after scrubbing the wound with a nail-brush and strong mixture (see p. 161), picking out dirt or foreign bodies with forceps, and clipping off portions into which dirt is obviously ground. In doing this the actual margins of the wound in the skin should be avoided, as it may be necessary to stitch them together subsequently; all the deeper

parts, especially anywhere where dirt is present, should be thoroughly swabbed out with the acid. When the wound in the deeper parts is larger than the opening in the skin, the latter must be freely incised, so that the whole extent of the wound is fully exposed. In some cases, no doubt, where the soiling of the tissues is very slight, the strong mixture will suffice. A good example of a wound of this kind may be seen in a scalp wound where hairs and scurf are present in the wound. We shall therefore take it as a type, and describe the treatment in detail.

Treatment of a Scalp Wound.—In the first place, the hair should be shaved for at least two inches around the wound in all directions. When all the hair and dirt have been removed, the wound and the scalp around are thoroughly cleansed by turpentine, soap and strong mixture (see p. 161). If the wound has been caused by a dirty blunt instrument, it is well after arresting the bleeding to swab the cut surface with undiluted carbolic acid. In all these cases drainage should be employed, lest asepsis has not been obtained in spite of the above vigorous measures. A drainage tube of a size varying according to the extent of the wound, and always of fairly large calibre, should be inserted at one angle, and should extend into any recess or pocket that may be found beneath the scalp. After the wound has been disinfected and drained, the hair in the vicinity should be thoroughly impregnated with a paste made by mixing the double cyanide of mercury and zinc with 1-20 carbolic lotion; this is rubbed thoroughly into the hair, which is thus readily converted into an antiseptic dressing. If the wound be an incised one, it may now be sewn up by several silkworm gut stitches; if it be a lacerated one, it is not necessary to devote any great care to the approximation of the edges of the wound, because the probability is that primary union will only be partial at best; just enough stitches should be employed to keep the flap in place. The usual antiseptic dressings are then applied in the ordinary manner (see p. 169).

If no pain or other signs of sepsis manifest themselves, the wound should be dressed in about four days and then, if there be no suppuration, the drainage tube may be left out and the wound allowed to close. If, however, the attempt to secure asepsis has failed (as will be evidenced by local inflammation and general fever), the dressings must be changed more frequently, but in no case is it advisable to wash out the wound with an antiseptic solution, as is so often recommended.

WOUNDS ALREADY SEPTIC.

Another group of incised wounds, not made by the surgeon, that demand consideration are those in which several days at least have elapsed between their infliction and the time they come under the surgeon's notice. Wounds of this kind may be divided into open granulating wounds, and those in which there is only a small opening at the surface and a deep track running inwards; this latter condition is known as sinus or fistula.

Treatment. — (*a*) **Of Open Granulating Wounds.** — Unless these wounds are extensive, involve important structures, or are situated on parts exposed to frequent movement, they generally heal pretty readily, so long as there is free exit for the discharges. The first essential in treatment is to see that there is no retention of discharge anywhere, and if the inflammation be only slight the ordinary antiseptic cyanide gauze dressing (see p. 169) may be used and changed daily; where, however, the discharge is foul, the use of iodoform in addition to the gauze dressings is indicated. Where there is much inflammation in the wound and the neighbouring parts, and especially if the wound be lacerated or contused, constant irrigation (see p. 30) may be usefully employed. Wherever the wounds are in important situations, such as the palm of the hand, or close to and involving tendon sheaths, bones, and the like, it is advisable in addition to make an attempt to obtain thorough and immediate disinfection of the part. This can only be done by putting the patient under a general anæsthetic, scraping away the whole of the granulation tissue from the surface of the wound with a flushing spoon (see Fig. 55), and sponging it over with undiluted carbolic acid. Iodoform may then be liberally sprinkled over it and the ordinary cyanide gauze dressings applied. Where the wound is more or less superficial and freely exposed to view, this procedure will generally secure its disinfection. If there be any objection to the administration of an anæsthetic, and if the wound be small, a similar result may be obtained by stuffing it with lint or gauze soaked in strong carbolic oil (1-5) and applied to the wound without being wrung out; the stuffing is changed night and morning, and the surrounding skin is washed with a 1-20 carbolic acid solution. The strong carbolic oil does not actually act as a caustic, but it prevents healing, and therefore, as soon as the wound has assumed a healthy appearance, it should be discontinued and strong boracic ointment used till healing at the edge commences, when the weaker ointment ($\frac{1}{4}$ strength) is substituted.

(*b*) **Where Septic Sinuses are present.**—Where septic sinuses are present within the area of operation, as, for example, in removing necrosed bone, they should be thoroughly scraped out with a sharp spoon, and swabbed with undiluted carbolic acid, before the operation is begun, so as to avoid infection of the freshly cut surface as far as possible. After the operation has been completed, the septic cavity must be again scraped thoroughly, and undiluted carbolic acid applied, and the walls of the sinuses should be cut away as completely as possible. In this way, an aseptic wound will be obtained in a considerable number of cases; the edges can then be brought together by silkworm gut stitches, (after the insertion of one or more large drainage tubes into the depths of the wound), the ordinary antiseptic dressings applied, and the wound treated as if made through unbroken skin. Should the attempt to purify the wound fail, the best and simplest dressing is boracic ointment or boracic lint.

Where, however, the cavity in the deeper parts is large, as after operations

for necrosis, it is best to stuff the wound from the first with cyanide gauze, and then to apply the ordinary gauze dressing outside. Unless this be done, the opening in the skin is likely to close so rapidly that the discharge from the deeper parts does not escape freely, and healing cannot occur; besides this, the irritation of the gauze leads to unduly rapid growth of granulations, which thus fill up the wound. Under these circumstances, the external dressing should be changed on the day following the operation, and subsequently as often as the amount of discharge present may require. The stuffing should not, however, be removed unless it be quite loose; it should be gently pulled upon at each dressing and any loose portions cut away, but where the wound remains aseptic it may be two or three weeks before it can all be removed. After the loose portion has been cut off, a little fresh gauze should be laid on the remaining stuffing so as to fill up the cavity. Should the wound become septic, the stuffing comes away quite readily, and it should then be renewed daily until the cavity is almost entirely filled up. There is always great trouble with the opening in the skin, which constantly tends to close and leave a narrow sinus leading into a comparatively large cavity. Where it is evident that a long time must elapse before a cavity can fill up, it is a good plan to cut away a considerable portion of the skin around the margin of the opening at the time of the operation; any overhanging portion should always be cut away, as it would only become inverted and delay healing. There is sometimes a good deal of trouble caused by inversion of the edges of the skin during the progress of healing, and if this occurs a little cocaine may be injected (see p. 121), and the inverted portion cut away. When the granulations are near the surface, the stuffing should be given up, and weak boracic ointment substituted.

CHAPTER IX.

WOUNDS.

PUNCTURED, CONTUSED, LACERATED AND POISONED WOUNDS; BURNS, SCALDS, AND FROSTBITES.

PUNCTURED WOUNDS.

Characters.—A punctured wound is one made by a narrow instrument so that its superficial area is small in proportion to its depth; in it there is generally a comparatively small opening in the skin leading into a large irregular wound in the deeper parts. The peculiar features of the punctured wound are due to the elasticity and contractility of the injured parts; the elasticity of the skin tends to diminish the opening in it and, on the other hand, the contractility of the muscles beneath tends to increase the size of the wound in them.

Results.—The results of punctured wounds depend very much on the particular structures injured. Where no important structure is wounded the pain is usually slight and the hæmorrhage trifling. If, however, an artery be punctured, most profuse bleeding will result; and, as we shall see when we come to speak of injuries and diseases of arteries, this is the usual way in which a false aneurysm is produced. In punctured wounds of the abdominal wall, the instrument may penetrate the abdominal cavity and injure one of the viscera, and special symptoms will then occur, the characters and treatment of which will be considered under affections of the particular organ in question. Further, if the instrument which caused the puncture pass through clothing, or if the puncture be in a hairy part, infective material is very likely to be carried into the soft parts, and a septic wound may be thereby produced.

Treatment.—It is advisable, in all cases of punctured wounds, to enlarge the aperture in the skin sufficiently to give thorough access to the deeper parts, which should be cleaned out, the blood clots removed, and the hæmorrhage arrested. The wound should then be thoroughly washed out with a 1-20 solution of carbolic acid, any large muscle that happens to be divided should be stitched together, and any other im-

portant injury to the deeper parts (*e.g.* division of nerves) repaired. When this has been done the incision which the surgeon has made, in order to gain proper access to the wound, should be stitched up, and a small drainage tube inserted at the seat of puncture. As a matter of fact, the puncture would seldom heal by first intention if the edges were brought together throughout, and besides this, one can never be certain that all the septic material in the interior has been destroyed, and, therefore, it is well to leave an opening in case sepsis should occur.

CONTUSIONS AND CONTUSED WOUNDS.

Characters.—By a **contusion** is understood a severe bruising of the tissues unaccompanied by rupture of the skin. The parts which are subjected to the bruising are more or less torn and hæmorrhage occurs into them, so that if a contused area be opened up it is found to be partly torn and partly infiltrated with blood clot.

When the skin is torn at the same time a **contused wound** is produced, and this is characterized by irregularity of the rent in the skin and raggedness of the edges, which are much bruised and infiltrated with blood, the deeper parts of the wound and the parts around are also bruised and bloody.

Causes.—Contused wounds are caused by crushes, run-over accidents, bites, gunshot injuries, and the like. As a rule there is not much bleeding, the vessels being torn and blocked; there is often great pain, and the healing of the wound is always slow. Should it become septic, there will be suppuration and sloughing of portions of the contused tissues; if it remain aseptic, healing of the deeper parts takes place by blood clot, and this is naturally a prolonged process.

Treatment.—In the case of a simple **contusion**, the first object is to prevent any increase in the hæmorrhage that has already taken place. If the contusion be large, an icebag, or, if small, an evaporating lotion (see p. 8) should be applied for the first 8 or 10 hours; the limb or the affected part should be kept at rest, upon a splint if necessary, in the elevated position. As soon as it is evident that no fresh effusion is going on, the indication is to promote the absorption of that already poured out, and for this purpose the starch and cotton-wool bandage is most efficacious (see p. 21). After a few days, when the bulk of the poured-out blood has been absorbed, the disappearance of the remainder is greatly facilitated by careful massage (see p. 22). When the damage to the muscle is severe, other measures may be required, but this will be dealt with again later on in connection with injuries of muscles.

The treatment of a **contused wound** is directed primarily towards securing perfect asepsis; the tissues are so much damaged by the injury and so much blood is extravasated into them that they are very liable to become the seat of severe septic inflammation, even though the organisms that

have gained access to the wound be not very virulent. As a first step, free access must be provided to the deeper parts, and for this purpose the skin wound must be enlarged, if necessary, so that the whole wound can be purified. The particular method employed for purification will depend to a considerable extent on the cause producing the wound. Where the skin is burst rather than actually torn or cut by an instrument, and the case is seen immediately after the receipt of the wound, the chances are that septic organisms have not penetrated deep. On the other hand, where the patient has fallen on stones or been run over by the wheel of a cart, the probability is that dirt containing septic organisms has been firmly ground into the tissues. Hence, in the former case, it is sufficient to thoroughly wash out the wound with 1-20 carbolic lotion, or, perhaps better, with strong mixture (see p. 162), and, if the tissues be at all obviously soiled, to scrub the skin with a nail-brush and strong mixture. In the second class of case, where dirt is evidently ground into the tissues, and more especially where bone is injured, it is best first of all to clip away any very dirty tissue and any tags of skin and muscle, and then to wash out the wound with strong mixture, and finally to sponge it over with undiluted carbolic acid. Naturally, in these bad cases, the patient should be put under a general anæsthetic while the wound is being cleansed. No stitches whatever should be employed; the wound should be left freely open. The best dressings to use at first are the ordinary cyanide gauze and salicylic wool, and, should the wound prove aseptic, a piece of protective should be applied to its surface after a day or two, in order to prevent the irritation that this dressing would otherwise cause. After a time, if a considerable raw surface be left, and especially if it be granulating well, skin-grafting may be usefully employed (see p. 50). Should suppuration occur in these contused wounds, and should there be much local inflammation and a tendency to sloughing, then irrigation is the best treatment, and it may be carried out in the manner already described (see p. 30). As soon, however, as the wound becomes covered with granulations, irrigation should be discontinued, and either the gauze dressing employed, or, still better, one of the various antiseptic ointments. The best of these is the boracic ointment, the full strength being used until it is evident that healing has begun at the edge, and then half or quarter strength ointment substituted for it so as not to interfere with the growth of the young epithelium.

LACERATED WOUNDS.

Characters.—In lacerated wounds proper, namely, those caused by tearing, the bruising of the deeper tissues is not nearly so marked as in wounds inflicted by a direct blow with a blunt instrument. In lacerated wounds, except where a limb is torn off, the wound is usually comparatively superficial. Its characteristics are that the parts are much torn, and that there are shreds of muscle and fascia hanging about the

wound. These structures are more or less completely deprived of blood supply, and will slough should the wound become septic; in fact, they will probably do so in any case. The wound is usually much soiled, especially in machinery accidents, where dirt and grease are certain to be present, and great care must be taken in disinfection.

Causes.—These wounds are inflicted by a blunt instrument, which tears the tissues rather than contuses them; the most typical example of this is in machinery accidents, where a toothed instrument catches the skin and tears it off for a considerable distance. Lacerated wounds are always to some extent contused wounds, and a contused wound may also be a lacerated one.

Treatment.—The patient should be put under a general anæsthetic, all tags clipped away, and the part thoroughly scrubbed with a nail-brush and strong mixture, or even sponged with undiluted carbolic acid. It is useless to stitch the torn skin together; the most that should be done is to put in one or two stitches to keep the flaps somewhat in position. If there be any tension, it will certainly lead to sloughing of the flaps, as their vitality is already much interfered with. The ordinary gauze dressings should be used at first; should suppuration and much local disturbance occur, recourse must be had to irrigation with weak Condy's fluid or sanitas, in the manner already described (see p. 30). Many of these wounds will, however, heal by blood clot if they are small and are rendered aseptic by the purification described above; at any rate, the greater part will heal in this manner, though possibly after a time granulation may form towards the centre of the wound from the irritation of the dressing. When the wound is aseptic, there will be comparatively little separation of sloughs either from the skin or from the deeper parts, the aseptic slough, like a blood clot, acting as a mould in which new material is formed.

Where much skin is torn off an extremity, the *question of amputation* has to be considered. Such wounds, for instance, as those where the whole skin of the forearm has been lost, often do not heal at all on account of the large size of the sore, or if they do, so much contraction results that the movements of the joints are permanently interfered with, the result in bad cases being so unsatisfactory that amputation is often considered better practice. It is well, however, to bear in mind that many of these cases can be got to heal by skin-grafting, and a very useful limb may result, so that the former rule of amputating in all cases where the loss of skin from a limb is very extensive, does not apply so absolutely at the present time. In many cases, by allowing the wound to granulate, and then, after scraping away the soft granulating material which has already formed, applying Thiersch's skin grafts (see p. 50) before contraction has taken place, extensive wounds can be induced to heal without any marked contraction; and there is always this to be said in favour of attempting to save limbs which at first do not promise well, that amputation can be performed later on should it be found that, after all, the functional result is not satisfactory.

Even after skin-grafting has been employed, the great tendency to contraction during healing in these cases must still be borne in mind, and must be counteracted by the careful application of splints. For example, in the case of loss of skin and fascia at the bend of the elbow, the arm must be kept carefully extended by means of an anterior splint; where the loss is about the back of the hand, it is well to keep the fingers flexed during the healing process, the principle being that, if contraction be likely to occur in a certain direction, it is best counteracted by fixing the limb on a splint bent in the opposite direction. It must also be borne in mind that the tendency of the scar to contract does not by any means cease when healing is complete; a young scar will go on contracting for a considerable time, and this tendency will continue for three or four months at least. Hence, when the skin over a joint is involved, the use of a splint must be continued for at least that length of time after the wound has healed. It may not, perhaps, be advisable for the patient to wear the splint night and day for the whole time, as certain movements of the joint must be allowed in order to keep up its mobility and the nutrition of the muscles about it, but certainly for two or three months the splint should be constantly used, and then it may be left off during the day, and only applied during the night for another period of about three months. Massage and passive movement which will also be called for, in order to ensure proper movement in the neighbouring joints, and to restore tone to the muscles, will prove valuable auxiliaries in stretching the scar.

POISONED WOUNDS.

VARIETIES.—In speaking of poisoned wounds, reference is usually made only to those following *post-mortem* examinations, dissections, or operations, especially upon parts containing foul pus, etc. We shall restrict the term here to these conditions. The most common variety is the *post-mortem* wound, and there are three distinct varieties of infection which may arise in this connection.

(a) **Lupus Anatomicus.**—This is the mildest form, and is also known as anatomical warts. It consists of warty growths which appear on the fingers of pathologists and *post-mortem* porters, and which are really of a tuberculous nature. The soft warts are often very rebellious to treatment, and in a certain number of cases they give rise to disease elsewhere, for example, tuberculous glands in the axilla or above the elbow, infection of neighbouring joints or sheaths of tendons (tuberculous synovitis, or teno-synovitis), lung disease, etc. Hence it is important to recognise and remove them as soon as possible.

Treatment.—The best treatment is to excise the growth, going wide of it in all directions; provided that the wart be small, the result is quite satisfactory. After excision a skin-graft is applied to the raw surface, and subsequent contraction is thus avoided. Even where the warty growth is

extensive, it can best be got rid of in this way; should the tendons be exposed in the dissection, loss of movement need not be feared so long as the whole raw surface is well covered with skin-grafts.

Where the patient refuses excision, or where for any reason the surgeon does not wish to employ it, an anæsthetic should be administered and the warty material thoroughly scraped away; after the bleeding has been completely arrested, the surface should be vigorously rubbed over with nitric acid (not merely daubed on with a sponge or piece of wool dipped in it), which should be allowed to act for from five to ten minutes. At the end of that time a strong solution of carbonate of soda (an ounce or more of carbonate of soda in a tumbler of water) is poured over the sore to neutralise the nitric acid; the effect of the soda solution is to cause vigorous effervescence from the formation of carbonic acid, but, as soon as the nitric acid is completely neutralised, this ceases. The surgeon should, however, always impress upon the patient that by far the best method of treating this disease is by excision and subsequent skin-grafting.

(b) **Local Septic Infection.**—The other troubles which arise from *post-mortem* wounds are septic infections, either local or general. The results of local septic infection vary in severity from the formation of a small pustule or abscess, to an extensive diffuse cellulitis spreading from the fingers up the hand and arm; the treatment of these conditions is that already described for acute abscess or diffuse cellulitis (see Chap. II.). We need not refer to it again here.

(c) **General Septic Infection.**—The most serious result of a *post-mortem* wound, however, is acute septicæmia, and this is perhaps most likely to occur in wounds inflicted accidentally in making *post-mortem* examinations on patients who have died of suppurative peritonitis; the organisms in the pus are here particularly virulent. The disease progresses with great rapidity, and the patient soon passes into the typhoid state, and may die in from 36 to 48 hours.

Treatment.—In this acute form of septic poisoning there is very little hope of a successful result, as the disease is far too rapid for any satisfactory intervention. The infection is most often due to streptococci, and, therefore, at the present time we should be inclined, as a first step in the treatment, to inject a quantity of the antistreptococcic serum. In its present strength about 20 c.c. should be injected when the patient is first seen, and this should be followed up by a further 20 c.c. in the course of 10 or 12 hours. Apart from this, the treatment chiefly consists in the employment of stimulants, such as brandy in ounce doses given at intervals of from two to four hours according to the gravity of the case, the administration of as much nutritious food (beef essences, egg, and milk, etc.) as possible, and the use of large doses of quinine. This drug should be given in doses of five grains at a time, every three hours, or Warburg's tincture in drachm doses at similar intervals may be substituted

for it if symptoms of quinism develop. The wound should be swabbed out with undiluted carbolic acid, but the local symptoms are usually very slight and seldom require any special treatment. This acute form is extremely fatal, and, in spite of anything that may be done, the probability of the patient's recovery is very slight indeed. We shall return to the subject again in dealing with infective diseases of wounds (see Chap. X.).

BURNS AND SCALDS.

Causes.—Burns and scalds are caused by contact with solids, liquids, or gases, at a high temperature. Radiant heat only causes quite superficial burns, such as blisters and erythematous conditions of the skin. Liquids below 212° F. cause erythema, but at or above that point they produce extensive burns, especially if the liquid has fallen upon the clothes, because, before the patient has time to divest himself of his clothing, the liquid has remained in contact with the skin for some considerable time. Caustic liquids cause extensive sloughs. Red-hot or white-hot solids cause deep and limited lesions; fused metals are extremely rapid in their action and char the parts completely.

Degrees of Burn.—The **local phenomena** of burns are, as originally proposed by Dupuytren, usually described under six headings or degrees. The **first degree** is caused by the transient action of a flame, or by a body below 212° F., and is marked by redness of the skin, followed by some swelling and pain, and subsequently by desquamation. The **second degree** is caused by a more prolonged action of a flame, or by boiling water, or by solids at 212° F.; and in this case the Malpighian layer of the skin is disorganised, and inflammation, as shown by erythema and the formation of bullæ, follows. The **third degree** is reached when one of the foregoing causes has acted for a longer period, or where the burn is caused by red-hot metal, boiling salt water, or oil. Here there is destruction of the epidermis, the Malpighian layer, and the papillæ of the skin, the result being that there is erythema, the formation of bullæ and superficial dry eschars; the slough separates in from about six to seven days. The **fourth degree** is where the whole thickness of the skin and part of the subcutaneous tissue are destroyed; in it there is a black eschar with a white circle around it, and then beyond that a zone of redness. There is less pain in this form of burn, but the healing is slow. The **fifth degree** is where not only the skin but the subcutaneous tissue and portions of the muscles are completely destroyed; it is due to the long-continued action of flame or red-hot metals, or to chemical substances such as arsenious paste, caustic potash, etc.; a dry slough is formed, and surrounding this there are the various minor degrees of burns, from sloughing of part of the skin in the neighbourhood to simple erythema at a distance. In this form of burn, the joints are frequently opened, especially as the slough separates, and very serious results may consequently ensue. The **sixth degree** of burn is

where all the tissues of the limb are charred, and where there is complete destruction of the part subjected to the heat.

Among the later effects of burns is the occurrence of a certain amount of inflammation around the burnt area, due directly to the action of the heat; and besides this, if the parts have not been rendered aseptic, there may be septic infection with severe local and general results. Later on there is the separation of the slough, granulation, and healing.

The **constitutional phenomena** are divided into three stages, which need only be alluded to. The *first stage* lasts for 48 hours, and is marked by congestion of the parts in the neighbourhood of the burn, and great pain; besides this there may be congestions of the internal organs. Thus, for example, when the burn is situated over the thorax, the pleura or the lungs may become congested; when it is over the skull, the meninges may be similarly affected, and so on. During this stage also there are other serious dangers; for instance, shock, delirium, convulsions, asphyxia from carbonic acid or carbonic oxide or death with symptoms of poisoning attributed to absorption of the partly broken-up products of the burnt tissues. The *second stage* of burns lasts from the second to the sixth or eighth day, and is termed the inflammatory period: this is marked by inflammation of the part with sloughing of the dead tissues, and a tendency also to inflammation of the internal organs; for example, a burn over the head may be accompanied by inflammation of the brain, a burn over the thorax by inflammation of the pleura or the lungs, and so forth. It is during this stage that the peculiar phenomenon frequently noticed in burns, namely, inflammation and, in some cases, ulceration of the duodenum a little below the point of entrance of the bile duct, is observed. This occurs just at the point where the contents of the bile duct would impinge on the intestinal mucous membrane, and is possibly due, as was pointed out by Dr. William Hunter, to the excretion, with the bile, of irritating products resulting from an imperfect carbonisation of the tissues. The *third stage* begins when the slough separates, and is mainly occupied by the healing process: towards the end of the second, and in the early part of the third stage, the patient is liable to the various general septic diseases, which will be alluded to presently. He is also liable to local septic troubles due to the position of the burn; for example, when it is situated over a cavity such as a joint or the pleura, and the latter is opened as the slough separates, violent septic inflammation of the part (arthritis, pleurisy, etc.) may follow.

The Causes of Death after Burns depend mainly on the extent, but partly also on the depth of the burn and the region of the body affected. An extensive superficial burn is much more dangerous than a limited but deep one, whilst a burn over the head or the thorax is far more serious than a more extensive one on an extremity. The causes of death after burns are (1) shock, (2) collapse, (3) asphyxia from carbonic acid or carbonic oxide, (4) poisoning from absorption of partially broken-down organic products at the seat of the injury, (5) congestion of various internal

organs, (6) inflammation of these organs, (7) intestinal ulceration, (8) various septic diseases, particularly erysipelas, septicæmia, and pyæmia, and (9) exhaustion. In burns in particular situations of course there are special dangers; for example, in scalds of the throat there is the special danger of œdema glottidis and death by suffocation.

Treatment.—The treatment may be described under four heads, namely, the treatment of the first degree, that of the second, that of the third and fourth degrees, and lastly, that of the last two degrees. It is also important to describe both local and general treatment.

(*a*) **General Treatment.**—The general treatment will depend largely upon the extent and result of the burn. When a patient comes under observation, suffering from severe *shock*, the various measures appropriate for the treatment of that condition (see p. 141) must be employed.

During the early stage also, apart from shock, it may be necessary to counteract *carbonic oxide poisoning*, which is indicated mainly by the presence of dyspnœa, while the mucous membranes are of a cherry-red colour and the pulse is slow. A drop of blood from a needle-puncture shows marked deviation in colour from normal blood; it is of the same bright cherry-red as the mucous membranes. This condition is due to the carbonic oxide entering into combination with the hæmoglobin, and preventing the corpuscles from fulfilling their functions as carriers of oxygen.

Carbonic oxide poisoning must be treated by free stimulation, combined with efforts to promote the oxygenation of the blood. In all cases the principal benefit will be obtained from the inhalation of oxygen, and this should be the first thing thought of. Until it can be obtained, artificial respiration by Sylvester's method must be carried out if the breathing shows any tendency to flag. In most towns, cylinders of oxygen can be obtained, and, if one be at hand, one end of an india-rubber tube should be attached to the cylinder, and the other to a mouthpiece such as that of an ordinary Clover's inhaler, or, failing that, a piece of brown paper folded into a cone; a stream of oxygen is then turned on, so that it pours over the patient's nose and mouth in large quantities. In these cases, the oxygen inhalation to do any good must be continuous, the mouth-piece being removed perhaps every ten minutes or a quarter of an hour for a minute or two, and it must be gone on with for certainly from 12 to 24 hours, until, in fact, a sufficient number of new blood-corpuscles have been formed to act as carriers of oxygen. Where a cylinder of oxygen is not available, and time permits, the gas can, of course, be prepared in the usual manner by heating chlorate of potash (in quantities of half an ounce at a time) in a Florence flask over a Bunsen flame, and conducting the oxygen thus obtained through a suitable tube furnished with a funnel or face-piece for inhalation. Transfusion of blood has been suggested, but it seems that the blood-corpuscles thus introduced do not retain their vitality for any length of time, and act only very temporarily, if at all, as carriers of oxygen to the tissues. As a stimulant the subcutaneous administration

of caffeine in doses of one grain or more in solution, with an equal quantity of salicylate of soda, repeated in three or four hours, is of use; brandy will also be called for.

If, after the patient recovers from the shock, symptoms of internal congestion or *inflammation* set in, the treatment must be conducted partly on the principles indicated for acute inflammation and partly on the medical lines appropriate to the organ affected. During the stages of *sloughing* and *convalescence*, it is necessary to support the patient's strength, and for this purpose, the administration of a nutritious diet with plenty of milk, and the use of stimulants and tonics, is of the greatest importance. Of the latter, Blaud's iron in capsules containing ten grains, three times a day, or tinct. ferri perchlor, ten to fifteen minims given three times a day, are the best. Quinine in three grain doses thrice daily is also of great value.

(*b*) **Local Treatment.**—Of still greater importance is the local treatment, which may be considered in connection with the various degrees of burn. In the **First Degree** the erythema which occurs from radiant heat requires little or no treatment. The chief trouble complained of is the sensation of heat and burning in the part, and the use of some soothing application, such as cold cream or glycerine, which also acts by protecting the surface from contact with the air, will often relieve it: if not, lead or lead and opium lotion (see p. 9) will be efficacious.

In the **Second Degree** where there are blisters they should be punctured at the most dependent spot, and their contents let out. The epidermis however should not be clipped away, and the incision in the blister should only be sufficient to allow the fluid to escape. If made too large the epidermis is apt to peel off, exposing the papillary layer of the skin, causing a good deal of pain, and retarding the healing. Where the injury has not gone beyond the formation of blisters, it is hardly necessary to irritate the skin by the use of antiseptic lotions, more particularly because the denudation of the papillary layer does not entail any serious risk of sepsis; it is best simply to apply some antiseptic ointment over the blisters after they have been pricked and their contents let out. The most suitable application is the eucalyptus ointment of the Pharmacopœia, but weak boracic ointment (half or quarter strength) also acts very well.

The Third and Fourth Degrees.—Where there is partial or entire destruction of the whole thickness of the skin or of the deeper tissues, as is the case in the remaining degrees of burn, great care must be taken to keep the parts rigidly aseptic, because, after recovery from the shock and for the first week or two afterwards, the patient's greatest risks are connected with sepsis. How best to secure asepsis is a question of considerable difficulty, for it must be remembered that burnt parts absorb fluids with extraordinary rapidity, and this is especially the case with regard to carbolic acid. Hence, if this drug be freely used as a disinfectant in burns, the gravest symptoms of carbolic poisoning, possibly ending in the death

of the patient, may result. Therefore, beyond a very superficial and temporary application of the acid (or the "strong mixture"), the drug should not be used for the wound, and the chief reliance must be placed on sublimate solutions, for example 1-1000. If this be freely applied and the skin at the same time soaped, disinfection is very rapidly effected.

In burns, the heat itself has, for a time at any rate, disinfected the part, so that, should no subsequent soiling occur, as will be the case when the patient is seen quite soon after the accident, it is not necessary to employ the disinfectant with the thoroughness required in ordinary operations. This more especially holds good when the burnt part has not been covered with clothes; where however clothes have been over the part, the latter must have become soiled in removing them, and great care must then be employed in disinfection. As the patient is suffering from shock, and as the rubbing and washing necessary for disinfection are obviously very painful, additional shock will be avoided if a general anæsthetic (preferably ether) be administered.

Thus, the procedure in bad cases will be to put the patient under an anæsthetic, to soap and wash the burnt area and the skin around, at first lightly with strong mixture, and then more thoroughly with a 1-1000 sublimate solution, which is subsequently removed by douching, either with boiled water or with a weak sublimate solution (about 1-6000). The best dressing is one of cyanide gauze and salicylic wool, but the gauze must be thoroughly rinsed out in a very weak sublimate solution (about 1-6000 or 1-8000), and not in carbolic acid, on account of the facility with which the latter is absorbed. The dressing should be left undisturbed for two or three days if the temperature remain normal and the patient be comfortable; indeed, should there be no evidence of sepsis after two or three days, the dressings may be left on for a week or even longer. The advantage of a dressing of this kind is that while it keeps the part aseptic it also allows the discharge to dry on the surface, and a reference to the chapter on Gangrene (Chap. IV.) will show that one of the most important points in the treatment of that affection is to promote drying of the part. When the slough begins to separate (sometimes it does not do so, but becomes organised in the same way as blood clot), and the parts around are granulating well, one of the antiseptic ointments may be substituted for these cyanide dressings. The best is eucalyptus or the full strength boracic ointment. When the slough has separated the wound must be treated as a healing ulcer (see p. 48), and if of any size, the sooner it is skin-grafted the better (see p. 50).

The use of picric acid in burns has lately been strongly advocated by a number of writers. It is claimed for it that it allays more effectually than the ordinary applications the intense pain so often present, while at the same time it possesses antiseptic properties. It is generally employed in the form of a saturated watery solution, which may either be painted upon the burnt area with a camel's-hair brush, or may be applied by saturating

a piece of butter-muslin with it and laying it upon the part. The effect of the acid is to coagulate the albuminous fluid oozing from the sore, and thus to form a protective layer over the exposed nerve-ends in the skin. The application should be made once or twice daily, according to the size of the burn and the amount of discharge from it. If lint or muslin be used, it should be soaked off by warm boracic lotion. We have found the drug useful in burns of the smaller and more superficial variety: for the more severe ones we prefer the method just described.

It is especially necessary to warn the practitioner against certain applications for burns which are commonly recommended. Carron oil for example (a mixture of linseed oil and lime water), is a filthy application and is responsible for a great deal of the mortality after burns: the use of poultices or water dressings and dusting with flour are equally bad. As far as possible, the wound must be treated aseptically.

Should the case come under observation with a foul sloughing wound, or should the attempt at disinfection fail, and the wound become septic, the best method of treatment probably is the water bath. If, where the trunk is affected, the burn be large, very painful, or accompanied by constitutional disturbance, the patient is placed in a bath, the water (at a temperature of 100° F.) containing a small quantity of an antiseptic, such as Condy's fluid or sanitas, and being changed every three or four hours. The patient should be taken out of the bath at night, and wet boracic lint dressing applied; this consists of boracic lint soaked first in 1-20 carbolic acid, and then in warm saturated boracic solution to wash away the carbolic; it is applied wet, and covered with a piece of mackintosh (previously dipped in a 1-20 carbolic acid to asepticise it, and subsequently in boracic lotion). Next morning the patient is again placed in the water bath, and kept in till evening, and this method is continued until the sloughs have separated and the inflammation has subsided. There is then no further necessity for the bath, and the boracic dressings, antiseptic ointments or protective and boracic lint, applied as described for healing ulcers (see p. 47), should be substituted. Where the extremities are affected, the special baths already described may be used (see p. 33).

If the burn be of any size skin-grafting should be employed (see p. 50) as soon as any sloughs have separated and the wound has begun to granulate. This proceeding is especially necessary in burns, because the sores resulting from them have a peculiar tendency to contract. Sores left by burns heal much more slowly than open wounds made by the knife, probably because the heat not only destroys the vitality of the part immediately acted upon, but also impairs that of the tissues around, so that in the early stages the vital processes in them are not nearly so active as usual. Therefore, there is much more granulation tissue formed, and much greater subsequent contraction.

Where the slough is situated over a joint or a serous cavity, and there is reason to fear that either may be opened when the slough separates,

special care must be taken in the antiseptic management of the case, because, should the part become septic, there may be acute suppuration of the articular or the serous cavity, with all the evils which will be described when we come to speak of these conditions.

The Fifth and Sixth Degrees.—The treatment of the fifth and sixth degrees of burn has to be considered essentially in regard to the extremities; if the burn be situated elsewhere, the patient usually dies at once. Should, however, a burn of these degrees be upon the skull or parts of the trunk, and the patient survive, the aim of the treatment must be to render and keep the part aseptic, to support the patient's strength, and to wait until the slough separates; then if no vital part be involved, the defect will be gradually filled up with granulations, and a time will come when skin-grafting can be usefully employed. In the case of the extremities, however, when the tissues down to and including the bone are completely charred, or when only the fifth degree is reached, and the tissues are destroyed over a large area, the question of primary amputation arises. This question must be answered in the affirmative wherever the extremity is seen to be hopelessly destroyed; the only points for discussion are as to when and where the amputation should be performed. As a rule it is best to wait until the shock has passed off, for if, as is frequently the case, amputation be performed before this, the shock is very apt to be much increased, and to bring about a fatal result. In the majority of cases, if the part be roughly disinfected and wrapped up in an antiseptic dressing, it is quite safe to wait for from 12 to 24 hours, till the shock is at any rate partly recovered from, and then, taking care to employ all the measures calculated to prevent or minimise shock (see p. 139), amputation may be proceeded with. In determining the seat of the amputation it must be remembered that it is not necessary to go very far above the actually charred tissue; there is certainly no necessity for going above the region of the erythema. If the part be kept aseptic (and of course special attention must be devoted to the purification of the skin in the region of the amputation) this congestion will subside without leading to any trouble during the healing of the stump.

EFFECTS OF INTENSE COLD.

Local Effects.—The local effects of cold in some respects resemble those of heat. The parts chiefly affected are those most distant from the heart, such as the toes and the fingers (especially the great toe, and the little finger), the nose and the ears. Moist cold is more likely to do harm than dry, and where there is wind, frost-bite is much more likely to occur than where the atmosphere is still. The effect of cold is to cause great local contraction of the vessels, so that the part becomes at first livid and ultimately white. On the cessation of the cold, reaction

takes place; the vessels become greatly dilated, while if the reaction be too severe, stasis is apt to occur, and may end in thrombosis. Where death results from cold, the most common appearance met with *post-mortem* is thrombosis of the vessels of the internal organs. Various other local changes are described as the result of cold, the most important being degeneration or inflammation of nerves; these may possibly have something to do with the peculiarly languid ulcerations which affect parts that have been exposed to severe cold. The changes probably result from thrombosis or rupture of the nutrient vessels of the nerves.

The clinical effects of cold may be divided into three degrees. The **first degree** corresponds to the first degree of burns; it consists simply of erythema of the part, and is a reactionary phenomenon: the **second degree** corresponds, at any rate to a great extent, to the second degree of burns: and the **third degree**, or frost-bite proper, may be taken to represent the remaining degrees of burns.

Chilblains.—As the first effect of cold, therefore, we have erythema. The skin becomes of a wine-red or violet colour, which disappears on pressure; the cutaneous circulation is slow and there is some swelling of the skin and subcutaneous tissues, with a feeling of numbness in the part. If heat be applied too suddenly there is, in addition to this feeling of numbness, much itching and pricking. This condition generally disappears in a few days; if, however, the exposure to cold, followed subsequently by the application of heat, be repeated, it may lead to a more or less permanent condition known as chilblain, which, if not properly treated, may become cracked and ulcerated.

Ulcers.—The second degree of cold leads to the formation of bullæ containing clear or bloody fluid, and these again are apt to be followed by the formation of atonic ulcers which appear quickly and show little tendency to heal; there is also smarting in the part. Where the condition is yet more chronic we have what are practically ulcerating chilblains, the skin being swollen, œdematous, cracked, and marked by shallow fissures which yield a yellow or brownish liquid, very prone to dry up. These cracks enlarge and form obstinate ulcers.

Frost-bite.—The third degree of cold is where the skin and a varying amount of the deeper tissues die; the skin becomes livid and mottled and numerous large phlyctenulæ, containing rusty-coloured serum, are formed, or else sloughing takes place. If warmth be applied too quickly, the condition results in severe inflammation, followed by more or less extensive gangrene. The gangrene in these cases spreads slowly, and there is a tendency to an imperfect and temporary line of demarcation much the same as in the senile form; if opportunity be afforded, the dead part dries up, but the gangrene is not typically a dry one from the first. In other cases the sloughing is quite superficial, and the frost-bite is followed by permanent mal-nutrition, with anæsthesia, analgesia, or even atrophy of the limb, or the formation of perforating ulcers.

Treatment.—(*a*) **Prophylactic.**—The treatment of the effects of cold is partly prophylactic and partly curative. As a measure of prophylaxis, persons who must necessarily be exposed to severe cold should take large quantities of fatty food. The clothing should be thick and woollen, it should not be tight-fitting, and the feet especially should be kept warm; the body, particularly the exposed parts, should be oiled in order to prevent evaporation, and when the patient is exposed to intense cold he should keep actively moving, and must not yield to the desire to rest or sleep, which is often very great.

(*b*) **Curative.**—1. **Of the First Stage.**—Where the cold has, so to speak, got hold of the patient, he should not be brought at once into a warm room, as otherwise the reaction is likely to be so great that thrombosis of the vessels occurs. The affected part should at first be rubbed with snow or cold water, while, after a little time, dry friction may be substituted, and then the heat very gradually increased. Dry friction should first of all be practised by the hand, for which slightly warmed cloths may afterwards be substituted, and then the patient may be exposed to the air of a warm room at a distance from the fire. When this stage has been passed and the erythematous condition has supervened, the best applications are stimulant lotions, such as camphorated alcohol, rubbed into the part. The question of food is also important. At first both food and drink should be quite cold, and only gradually should warm nourishment be permitted.

Treatment of Chilblains.—Where chilblain is present and the skin is still unbroken, various applications, in which flexile collodion is the vehicle, are of great use. The following are the most valuable. Where there is great itching, the irritation can be much relieved by the application of flexile collodion containing 2 per cent. of cocaine. In painting this on a chilblain affecting, say, the toe, great care must be taken not to surround the base of the toe completely with it, as otherwise the contraction which ensues as it dries will exercise a certain amount of constriction which will interfere with the return circulation. The collodion should, therefore, only be painted on the main portion of the chilblain, and on one side (in the case of the great toe, the outer side) no collodion should be applied. Where the chilblains are very tender, the use of turpentine is of advantage, and the following prescription is very satisfactory:

℞ Collodion, - - - -	2 oz.
Venice Turpentine, - - -	6 drachms.
Castor oil, - - - -	3 drachms.

In this preparation the turpentine does not allow the collodion to dry completely, and the stocking is consequently apt to stick to the skin; it is well, therefore, to place a piece of boracic lint around the toe outside the collodion as soon as it has partly dried, and this can afterwards be removed with warm water. This application should be renewed at least

once a day, or oftener if the patient has been walking about. The use of glycerine and belladonna (glycer. belladonnæ, B.P.) over the inflamed part is also of value, and it is more suitable where the chilblain completely surrounds the toe; a piece of boracic lint is covered with the preparation and wrapped round the toe.

Where the chilblains are *ulcerating*, the best application is balsam of Peru; a piece of lint soaked in the balsam, and with some excess of it on the surface, is applied over the sore. In changing the dressings, the use of warm boracic lotion to bathe the part is sufficient; the application should be renewed night and morning.

A patient suffering from chilblains derives great benefit from the use of cod liver oil and syrup of iodide of iron internally, a teaspoonful of cod liver oil with 20 to 25 minims of syrup of iodide of iron being taken three or four times a day. Nourishing diet, with plenty of fatty food, should be given, and when the chilblains affect the feet, and have ulcerated, every effort should be made to induce the patient to lie up, or at least to refrain from walking.

2. **Of the Second Stage.**—In the second stage of cold, the use of stimulant lotions or balsam of Peru (see p. 202) is best in the first instance. As the ulceration in this case is usually of an atonic form, everything possible should be done to increase the nutrition of the limb. Massage applied to the whole limb above the limit of the sore will keep the circulation active, and will be of great benefit; in the same way electricity applied to the part in the form of electric baths, or the Faradic current applied to the muscles, and used in precisely the same way as for cases of Raynaud's disease, is of great value. These methods have been described in detail (see p. 73).

When the sore begins to heal, quarter strength boracic ointment may be substituted for the balsam of Peru. The part should be elevated, but it may not be necessary to keep the patient in bed, rest on a sofa often being sufficient; this point must, however, be determined by seeing how the ulcer progresses. If it does not heal, or if it shows signs of spreading when the patient is allowed to remain on the sofa, rigid confinement to bed, with the foot elevated, must be enforced. Cod liver oil should be administered internally, along with stimulants and a nutritious diet.

3. **Of the Third Stage (Frost-bite).** — The treatment of the third stage, or that in which gangrene occurs, remains to be considered. In the first place, the part should be thawed by friction with snow (see p. 201), and then wrapped up in cotton wool. If, however, the frost-bite is evidently severe, it is as well to set to work at once to disinfect the part, scrubbing the skin with strong mixture and turpentine, shaving it, cleaning the nails, and so forth, as has already been described with regard to gangrene (see p. 64), and then wrapping up the limb in cyanide gauze and salicylic wool. Immediate amputation should not be performed; it is

advisable to wait for a line of demarcation. It is not uncommon to find that, after all, the slough only involves the skin and subcutaneous tissues, or even only the surface of the skin, and by waiting a little it may turn out that amputation is not called for. In any case, there is no guide to the proper place for amputation till some sort of line of demarcation has formed, for it is impossible to say at first to what extent the tissues have been so damaged by the cold as to cause their death. As soon, however, as there is a clear indication of the extent of the frost-bite, there is no necessity to wait any longer, and amputation may be at once proceeded with. In most cases of frost-bite of the foot, a Chopart's or Syme's amputation will suffice: it is seldom that the gangrene reaches the ankle. If, however, the surgeon wait too long, the gangrene is apt to spread (as is the case with the senile form), the weak tissues being unable to resist the inflammation associated with the separation of the dead part. On the other hand, if the amputation be performed antiseptically, no further inflammation occurs, and there is no gangrene of the flaps. Thus, by waiting too long, more tissue may be lost than if the amputation were performed as soon as the appearance of a line of demarcation indicates the extent of the original gangrene.

The general treatment of the third stage of frost-bite is the same as that of the less severe forms (see p. 203).

CHAPTER X.

WOUNDS.

INFECTIVE DISEASES OF WOUNDS.

In the preceding chapters we have laid the very greatest stress on the aseptic management of the wound, but no consideration of the subject would be complete unless reference were made to the various results which may ensue either when these precautions have not been taken, or when they have been inefficiently carried out.

In connection with the various septic diseases that may attack wounds, it must be remembered that, although we shall describe such affections as septic intoxication, traumatic fever, septicæmia and pyæmia as different conditions possessing clearly differentiated symptoms and a definite pathology, yet in actual practice there are numerous gradations between them, so that it is often impossible to say when one ends and another begins. Thus a condition of septic intoxication very readily passes into one of traumatic fever, which in its turn may end in one of the forms of septicæmia or of pyæmia. Even septicæmia and pyæmia, which are the two members of the group that differ most widely, may both occur as the result of the septic infection of the same wound. Indeed, seeing that in all probability the same organisms may be concerned in most of these affections, it is not altogether illogical to regard the latter as being merely a series of varieties of the one fundamental condition of septic contamination, the particular form that the affection takes depending upon a variety of factors, such as the virulence and concentration of the infective material, the distribution of the organisms, and the anatomical conditions of the part affected, etc.

SEPTIC INTOXICATION.

The organisms which gain access to wounds may be either saprophytes, *i.e.*, those growing in dead tissues or in fluids, but having no power of penetrating into the living body, or parasites, *i.e.*, those which live and flourish in the bodies of animals whose tissues or fluids furnish suitable media for their development; the latter group are usually capable also of

saprophytic growth. Although the true saprophytes are unable to grow in the living tissues, they may nevertheless cause very serious results and may even bring about the death of the patient whose wounds they infect, for, as a result of their growth in organic materials, various poisonous substances are produced, which if absorbed into the body, may give rise to the condition known as septic intoxication. Septic intoxication therefore is an affection produced not by parasitic growth in the body but by the absorption of products of decomposition formed in the wound. These products are mainly the result of the growth of saprophytes, but they are also to some extent produced by organisms which can become parasitic should the patient live.

Symptoms.—The symptoms of septic intoxication are due to the poison which is absorbed into the system, and the condition in former days was not recognised as such and was often spoken of as "secondary shock." The affection can only occur in large wounds, because it is only in them that sufficient toxic material can be formed to provide a poisonous dose; for example, it may be met with in amputations at the hip joint, operations upon large joints such as the knee, extensive compound fractures, extensive operations about the breast and axilla, many abdominal operations, psoas abscess and so forth. The clinical history is somewhat as follows. In the first place, the operation being a severe one, the patient suffers more or less from collapse, with depression of temperature, feeble pulse, etc., and this is followed, as the shock is recovered from, by reaction with pyrexia. The temperature usually rises considerably within 24 hours; then it falls rapidly and the patient again passes into a condition not unlike that of shock. He becomes semi-conscious, the pulse is weak and fluttering, and the temperature low; if this condition persist, he may die. The affection is graver in those who have renal disease, for whereas the poison is very rapidly excreted by the healthy kidneys, the excretion may not be sufficiently rapid to save the patient's life if they are diseased. Hence the old rule, on which so much stress was laid, was that, where there was albumen in the urine, no operation should be undertaken. Nowadays, since we do not anticipate such a catastrophe as septic intoxication, this does not apply with such rigour. Milder conditions of septic intoxication may also occur, in which there is no great lowering of temperature; in them the patient rapidly recovers.

Treatment.—(*a*) **Local.**—When the above symptoms appear, the clear indications are to wash away all decomposing materials from the wound, so as to stop the absorption, and then to support the patient's strength and to promote the excretion of the poison which has already entered the body. Hence, if the temperature, after having risen high during the first 24 hours, falls rapidly and remains subnormal, while, at the same time, symptoms of shock make their appearance, the wound should at once be opened up freely, the stitches taken out, and all the decomposing blood clot and other material cleared out. It should then be

thoroughly *irrigated* with a non-irritating lotion, such as a 1-10,000 sublimate solution, or, where the patient is in a very dangerous state, by boracic lotion, or sterilized water; it is well to employ these lotions at a temperature of about 104° F., which acts as a general stimulant, and does not damage the tissues. The stronger antiseptics such as carbolic acid should not be used for irrigation because there is really no possibility of disinfecting the wound by them, and they may be absorbed and render the patient's condition still more serious. The effect of using them is to cause the formation of a layer of coagulated fibrin on the surface of the wound, beneath which the organisms are protected and may grow again.

After the wound has been thoroughly washed out, a few stitches are again inserted and one or more large *drainage tubes* introduced to provide free escape for the discharge. The cyanide gauze and salicylic wool is probably as good a dressing as can be applied; it should be changed and the wound washed out again through the drainage tube in the course of a few hours. Whether an anæsthetic should be given for the purpose of opening up and draining the wound depends on the condition of the patient. If he be in a very depressed state it is well to avoid it, as the procedure does not involve any great pain, and the anæsthetic might still further add to the depression.

Even in the case of septic absorption from the peritoneum, the abdomen should be opened and washed out. In such cases it must be remembered that the deleterious products will be in largest quantity in Douglas' pouch and in the flanks, and the tubes which are used to wash out the peritoneum should be especially directed to these parts. A useful method of rapidly washing out the peritoneal cavity consists in pouring a sufficient quantity of fluid (sterilized ·75 % salt solution at 104° F.) from a large jug into the

Fig. 61.—Keith's Glass Drainage Tube. The flange for securing the tube in position is seen at the left-hand end of the figure.

abdominal cavity while an assistant holds the edges of the abdominal wound apart. When the abdomen is full, the hand may be introduced among the intestines especially into the flanks and Douglas' pouch, so as to get the fluid thoroughly into contact with all the parts. The excess of fluid is then got rid of by gently compressing the abdominal walls and the process repeated several times. The fluid remaining may finally be taken up by sponges on forceps, introduced into Douglas' pouch, after raising the thorax slightly so as to encourage gravitation downwards. Then drainage tubes, preferably of glass, should be inserted into each flank and into Douglas' pouch. The best type of glass abdominal drainage tube is that known as Keith's (see Fig. 61). The flange at its upper end is made to project

beyond the skin, which is closely sutured around the tube: the latter should be long enough to reach down to the bottom of the cavity (*e.g.* Douglas' pouch) that it is desired to drain. If there be any likelihood of the tube slipping into the abdominal cavity it may still further be secured in position by cutting a small hole in a thin sheet of guttapercha (which must be scrupulously sterilized), stretching it and slipping it over the upper rim of the flanged end. A better plan is to have two holes drilled in the tube and to stitch it to the edges of the incision, in the way recommended for indiarubber tubes (see p. 27). The fluid collected in the flanks or in Douglas' pouch will not drain away through these tubes in the ordinary way and some special means must be taken to ensure its removal. This may be done by inserting down the tube a narrow twist of gauze which by capillary action sucks up the fluid and conveys it to the dressing. Besides this, at each dressing, any fluid there may be in the tube may be sucked up by means of a fine catheter, kept rigidly aseptic, attached to a glass syringe.

(*b*) **General Treatment**. Stimulants are of course indicated. *Brandy* must be given by the mouth or per rectum if necessary; in desperate cases it may even be injected subcutaneously. *Ether* in 10 to 20-minim doses may also be injected; the injection should be made into the muscles, for if it be merely introduced beneath the skin, a slough is apt to form afterwards. *Strychnine* is also of great value in this condition, a thirtieth of a grain being given subcutaneously and repeated hourly for two or three doses: its action is often increased by the addition to it of a hundredth of a grain of *digitaline*. Under the combined influence of these drugs the pulse becomes much steadier, for a time at any rate, and the patient's condition improves. Carbonate of *ammonia* in two or three grain doses, or sal volatile in half-drachm doses, may be given hourly. In fact everything must be done to keep the patient alive for a few hours until the poison in the blood has time to be excreted.

When recovery is taking place, the patient should be encouraged to drink large quantities of fluid so as to dilute the poison, and it is well to use the "imperial drink" referred to on page 14, which is also a diuretic. Vomiting is a very distressing feature in some cases and, should it persist, simple effervescing mixtures, such as effervescing citrate of caffeine in teaspoonful doses will often check it: a mixture containing five minims of dilute hydrocyanic acid with a drachm of liquor bismuthi to the ounce of water is also often useful. When convalescence is established a liberal diet must be ordered and tonics administered. When the wound has granulated further danger from this particular form of septic absorption disappears.

TRAUMATIC FEVER.

As long as the organisms that have gained access to a wound remain limited to the fluids or dead tissues in it, or are purely saprophytic in nature, they are only capable of giving rise to a condition of septic intoxi-

cation pure and simple. Should, however, any of the organisms producing this septic intoxication be capable of parasitic growth, and should they gain an entrance into the living tissues of the wound, the condition known as traumatic fever arises when the wound is of any size. This traumatic fever is due partly to the absorption of the products of saprophytic growth in the wound, and partly also to the entrance of pyogenic organisms; it generally continues until the establishment of granulation and suppuration. When it occurs, the reactionary pyrexia which often follows operations performed antiseptically, runs up to 103° or 104° F. instead of abating, and then slowly begins to fall in an intermittent manner, till about the fourth or fifth day, when it falls rapidly, the final descent coinciding with the complete establishment of granulation. This condition of traumatic fever, unless it end in septicæmia or pyæmia, does not usually prove fatal; at the same time suppuration always occurs in the wound, and attention must be especially directed to the local condition.

Treatment.—As soon as traumatic fever sets in, the wound must be dressed, and arrangements made for efficient *drainage.* Where no drainage has been employed, the wound should be thoroughly opened up and large tubes inserted. Where one has been inserted at the time of operation, the wound should be washed out with warm boracic lotion, with the object of getting rid of decomposing clots. This should be done at the first dressing, but should not be repeated at the subsequent ones; washing out a wound simply injures the delicate granulation tissue without killing the organisms which, being of the ordinary pyogenic variety, have already penetrated into the tissues. Thus, besides failing to disinfect the wound, it may, by injuring the granulations, enable the organisms to penetrate freely into the body and set up septicæmia or pyæmia.

The antiseptic dressings should be continued, and changed every day, and the surgeon must simply wait until he sees whether the condition merely ends in suppuration, or whether some more serious complication is going to arise. When the case ends in suppuration, the temperature falls about the fourth or fifth day, and the patient soon recovers.

The diet should be somewhat restricted, and, unless the temperature be high and the general condition bad, it is well to avoid the use of stimulants, or at any rate to give them only in very small quantities; during the acute sthenic stage of inflammatory fever they are not really called for. The patient should take plenty of "imperial drink" (see p. 14), so as to dilute the blood and keep the kidneys active; the bowels should be kept gently open with such saline aperients as seidlitz powders or drachm doses of sulphate of magnesia or effervescing sulphate of soda.

ACUTE SEPTICÆMIA.

This condition is much more serious than the one just described. Like it, acute septicæmia is also apparently due to the pyogenic organisms,

but the exact pathology is not very clear. It is sufficient for our purpose to point out that the affection is essentially one of poisoning by chemical products. The organisms themselves are not met with free in the blood in any large numbers, and they probably establish themselves either in the wound or in some of the internal organs, whence they pour septic products into the blood. Although the condition resembles that of septic intoxication in being due to chemical poisoning, it differs from it both by being exclusively caused by parasitic organisms, and by the fact that these latter have gained a footing either in the living tissues of the wound or in the internal organs. Acute septicæmia follows upon the condition of traumatic fever just described when the latter does not end favourably.

Symptoms.—The symptoms usually begin before the traumatic fever has subsided. The temperature, which has begun to fall, rises again to 103° or 104° F. and remains high, but with slight morning remissions of about a degree. Rigors are rare, but the patient feels ill and presents at first all the signs of sthenic inflammatory fever; in bad cases he soon passes into the typhoid state. Vomiting is not uncommon, and sometimes diarrhœa is present, though more commonly there is constipation. The urine frequently contains albumen, the wound is usually swollen and painful, and frequently the discharge from it is diminished in quantity or even completely arrested.

Treatment.—The treatment of acute septicæmia can only be directed to the symptoms, except perhaps in cases where an examination of the discharges from the wound shows that the condition is dependent on the presence of the streptococcus pyogenes, when the antistreptococcic serum should be injected in the manner indicated on page 183. Usually however, there is nothing to be done but to employ constitutional treatment, in the hope that the tissues may conquer in the fight against the organisms. It is especially necessary to support the patient's strength and hence a generous diet should be given, and as soon as the pulse begins to fail free stimulation will be necessary. If the temperature remains over 103° F., tepid sponging or some of the other antipyretic measures described on p. 215 must be adopted. In addition, large doses of quinine (five grains every three or four hours) should be administered until the patient shows signs of quinism, when the drug should be discontinued, or Warburg's tincture in drachm doses substituted. The bowels and the kidneys should also be kept acting (see p. 209). The disease is very fatal indeed; only a small number of those attacked recover.

The wound should always be opened up and drained freely, but there is no chance at this stage of really disinfecting it or of preventing the entrance of organisms into the body. A question which sometimes arises where the wound is in one of the extremities is that of amputation, and in a considerable number of cases this has been done. Unfortunately, however, amputation has very little effect on the progress of the disease, for in most cases the organisms seem to be established in the internal

organs, and the only effect of the amputation is to diminish the patient's vitality and to hasten the fatal result. Unless the source of the general condition be definitely limited to the wound or its vicinity, amputation is worse than useless.

CHRONIC SEPTICÆMIA OR HECTIC FEVER.

The condition known as hectic fever which is not infrequently met with is in reality nothing else than a chronic septicæmia; it may follow on the acute form in a few rare cases, but is generally chronic from the first. In it the temperature has a distinctly hectic character, being high in the evening (101° or 102° F.) and falling to about normal in the morning. In acute septicæmia also the pyrexia shows the same intermittent type, but there, notwithstanding the morning fall, the temperature is always a febrile one. The condition of hectic fever, indicated by the temperature, the occurrence of night sweats, wasting, dryness of the tongue, etc., usually does not come on till the chronic septicæmic condition has lasted for some weeks at least, and formerly it was ascribed to the loss of certain constituents of the blood resulting from prolonged suppuration. There can be no doubt, however, that it is due to the action of pyogenic organisms, which apparently do not grow in the blood and the viscera, as is probably the case in acute septicæmia, but are located mainly in the wound. After hectic fever has lasted for some time, a peculiar degeneration of the blood-vessels, termed *waxy degeneration* or *lardaceous disease*, takes place, and this chiefly affects the blood-vessels in the liver, the kidney, and the intestines; the result is that these vessels become leaky. Hence the amount of urine is increased, there is albuminuria, colliquative diarrhœa and œdema of the extremities. The waxy degeneration is due to the direct action upon the walls of the blood-vessels of the poisonous bacterial products circulating in the blood: it is not, as was formerly supposed, due to the loss of the purulent fluid. The affection is most frequently met with in association with tuberculous disease, necrosis, etc.

Treatment.—**Local.**—In a case of hectic fever the question of disinfecting the wound and getting rid of the source of the disease is naturally the first to arise. From this point of view, the cases may be divided into two large groups: (1) those in which the focus of the disease can be entirely removed, and (2) those in which this is impossible.

(1) **Where the focus of disease can be entirely removed.**—These cases may further be subdivided into those (*a*) in which some local operation is sufficient to get rid of the primary disease, and (*b*) those in which amputation is necessary.

(*a*) *Local operations*, such as the removal of a sequestrum, or arthrectomy of a joint, are called for wherever the extent of the primary disease and the anatomical conditions of the part are such as to offer a good chance of completely removing the cause of the mischief and ensuring thorough

disinfection of the tissues. In such cases the whole extent of the wound should be opened up, and left open, after either excising the focus of the disease completely, or scraping it out and sponging it with undiluted carbolic acid; it should then be packed well with cyanide gauze sprinkled with iodoform, extending to all the recesses of the wound. The outside dressing should consist of cyanide gauze and salicylic wool, and both that and the stuffing should be renewed daily.

(*b*) *Amputation* is called for under two conditions: (α) where the primary focus can *only* be removed by amputating the limb, and (β) where amputation is the *only safe* method of attaining that end.

(α) Perhaps the most familiar cases in which amputation is obviously the only means of eradicating the primary disease are those of extensive disease—generally tuberculous—of the knee, ankle, elbow, or wrist joints, accompanied by widespread suppuration and septic sinuses; any partial operation is quite powerless to arrest it, and nothing but an amputation performed through healthy parts will be of any avail.

(β) Sometimes amputation is the *only safe* method of treatment even when the local disease is but small in extent. Should the changes consequent upon the occurrence of hectic fever be so far advanced that the patient is completely worn out, there will be little good gained by any partial operation. Quite apart from the question of the deleterious effects produced by the shock and the loss of blood, which are often necessarily very considerable in an attempt to remove the diseased parts by dissection, the patient's condition is such that he cannot bear the strain of a prolonged period of healing, and amputation therefore offers the only chance. Although formerly the presence of waxy degeneration of the kidneys was supposed to be a bar to amputation, we find now that in amputation performed antiseptically this is not so. On the contrary, not only does the hectic fever subside after amputation, but the waxy condition of the organs tends to improve, the liver diminishes in size, the albumen becomes less and may ultimately disappear. Therefore, both with the view of saving the patient's life and of arresting the progress of the disease, amputation is clearly indicated.

(2) **Where the local disease cannot be entirely removed.**—The greatest difficulty occurs when the source of infection is on the trunk, as for example in psoas abscess. Here of course it is impossible to remove the source of infection entirely, but nevertheless the only chance for the patient is to render it as little virulent as possible. The best thing is to thoroughly scrape and wash out the wound with Barker's flushing spoon (see Fig. 55) and 1-6000 sublimate solution, and then to fill it up with iodoform and glycerine emulsion in the manner recommended for chronic abscess (see Chap. XIV). Another example in which treatment is very difficult is tuberculous hip-joint disease in which the pelvis is extensively involved. Here probably the best thing is to perform amputation at the hip joint, which serves the double purpose of removing a

considerable portion of the diseased tissues, and at the same time allowing free access to the mischief in the pelvis. By careful removal of as much of this as possible, followed by disinfection and free drainage of the wound (see above), the disease may be completely arrested. When hectic fever results from long-standing empyema, it may be cured by bringing about closure of the wound by Estlander's operation, or, failing that, by maintaining free drainage. Both these conditions will be referred to in more detail in their proper place.

General.—As in all other exhausting diseases, the general treatment is to support the patient's strength by nourishing food, fresh air, good hygienic conditions, etc., and to give tonics, such as iron and quinine, with stimulants if necessary.

PYÆMIA.

The gravest of the infective diseases of wounds is that known as pyæmia; it usually comes on from a week to ten days after an operation or an injury. The traumatic fever has generally passed off, and the temperature has nearly reached the normal, when the patient suddenly has a rigor, usually a very severe one, which lasts perhaps from twenty to forty minutes. The temperature immediately rises to 103° or 104° F., remains at that point for perhaps half an hour or more, and then begins to fall while, coincidently with the fall, there is profuse sweating. The phenomena of pyæmia thus very much resemble those of ague; there is first the cold stage, then the hot one, and finally the sweating. The temperature after the attack may fall in a few hours to what it was before the onset of the rigor, or even to normal, and for a day or two the patient may seem fairly well. Then there is another rigor, the same series of phenomena recurs, and so the case progresses, with constantly recurring rigors, the intervals between which steadily diminish, while the temperature in the intervals does not fall as low as before. The patient often becomes jaundiced, and signs of abscesses in the lung, joints, etc., manifest themselves, albuminuria develops, and death generally occurs about eight or ten days after the first onset of the disease.

Pathology.—Although pyæmia probably is essentially due to the same organisms as those that cause septicæmia, it differs widely from the latter, not only in its clinical characters but also in the pathological changes met with. From the point of view of treatment, the pathological condition in pyæmia is extremely important. The disease is undoubtedly due to the pyogenic organisms, the one most frequently found being the streptococcus pyogenes. The lesions found after death are abscesses in various organs, and suppuration in connection with various serous membranes; the abscesses are most numerous in the lung in the majority of cases, or in the liver if the wound be in connection with the bowel. The pathology of pyæmia is apparently that, in the first place, a vein in the neighbourhood of the wound becomes inflamed and thrombosed, and then organisms

grow in the thrombus, and gradually cause it to break up. Small portions containing virulent organisms are carried on in the blood stream and become impacted in the lungs, in the case of thrombosis of the systemic veins, or in the liver where the portal veins are the primary source of the mischief. Here probably the same process is repeated, and emboli are again given off and distributed by the arterial circulation, lodging in the kidney, the spleen, the synovial or the serous membranes, etc., where they give rise to abscesses. These secondary abscesses may also be caused by the growth of streptococci floating free in the blood; they form long chains which coil up into masses which are unable to pass through the smaller vessels, and in which they therefore become impacted. The most important point with respect to treatment, however, is that the disease is generally associated with thrombosis of a vein, and is due to the detachment of portions of clot from the blocked vessel. In its earlier stages at any rate, the disease is essentially a local one, and can be effectively treated by appropriate local measures.

Treatment.—(*a*) **Local.**—The first point is to search for a thrombosed vein. In the case of the extremities this will probably be the main vein of the limb. If a tender, inflamed and blocked vein can be found in the neighbourhood of the wound, it should at once be cut down upon, traced upwards to a point where it is still patent, a double ligature put on it there, and the vein divided between. Where feasible it is also advisable to dissect out the thrombosed vein and any of its communicating branches which may be similarly affected. If this be done at an early stage, when the patient has only had one or two rigors, the disease may often be completely arrested. The best example of what can be done in the way of checking pyæmia by this method of treatment is seen in cases of disease of the middle ear with secondary thrombosis of the lateral sinus. These particular cases will be dealt with fully under affections of the ear.

Besides the removal of the thrombosed vein, which is the most important part of the treatment, and really the only one that promises anything like a radical cure, there are various other points that should be attended to. In the first place, the wound itself should be disinfected, whether the vein has been removed or not. It should be thoroughly opened up, the pus washed away, the whole surface sponged with undiluted carbolic acid, and the granulations scraped away. It is well, before scraping away the granulations, to sponge them with undiluted carbolic acid, so as to get rid of any organisms lying upon the surface which might be carried by the sharp spoon into the deeper tissues; after the granulations have been removed, the raw surface left should be thoroughly impregnated with the undiluted acid. The wound should then be packed with cyanide gauze sprinkled with iodoform, or with iodoform gauze, and the ordinary gauze and wool dressing applied outside. The stuffing is renewed at first daily, and then at longer intervals, if the case does well. After a few days, when a fresh layer of granulations has sprung up, the stuffing may be discontinued,

a large drainage tube placed in the wound so as to make sure that the discharge escapes freely, and a stitch or two inserted when the wound is large. If the patient survive, and external abscesses develop, they must be opened early, and drained freely. When suppuration occurs in joints the latter must be opened freely and drained efficiently; this point will be dealt with fully in discussing the affections of joints. Further details as to local treatment in special cases will be given in connection with such affections as pyæmia after ear disease, acute osteomyelitis, etc.

(*b*) **General.**—Amongst drugs, the greatest reliance is placed on *quinine*. In most cases it is well to begin with a large dose,—from 15 to 20 grains of sulphate of quinine,—and then after three or four hours, to follow it up with five-grain doses every four hours, unless the patient shows signs of quinism, in which case it must of course be discontinued. *Salicylate of soda* may also be used,—20 grains every three hours,—watching also for signs of salicylate poisoning. The use of the sulpho-carbolates has been suggested with the idea that carbolic acid would be liberated in the blood, and would there help to destroy the organisms; as a matter of fact, however, the amount of carbolic acid that could be thus liberated would have absolutely no effect; and in practice the sulpho-carbolates have been found to be useless. Antipyretic measures must of course be employed when the temperature is unusually high, because after a rigor the patient may actually die of the hyperpyrexia. Of the antipyretic drugs, *phenacetin* is the safest. It may be given in 5 or 10-grain doses, repeated every hour if necessary, the pulse being carefully watched meanwhile for any sign of depression. *Antipyrin* is no doubt a still more effectual antipyretic, but it is a powerful depressant, and, where the patient is weakly, may produce an alarming degree of collapse. *Sponging* the body with water at about 90° F. is a very rapid and effectual way of reducing the temperature; it is very agreeable, and not at all depressing. The patient should be stripped and made to lie between blankets, and the sponging should be done under the blanket without exposing the surface of the body to the cold air; it should be continued for about ten or fifteen minutes, and the skin then carefully dried with hot soft towels. Care must be taken to maintain the temperature of the water used for sponging. Sponging should be repeated whenever the temperature rises above 102° F.

Stimulants will also be necessary, but they should not, in the early stage at any rate, be pushed to extremes, not more than about six ounces of brandy being given in the twenty-four hours. At a later period a larger quantity may be required, and the more diffusible stimulants, especially champagne, are the most useful. Given with or immediately after food, they produce a temporary stimulation and aid the process of digestion.

The *diet* should of course be essentially liquid; the patient is unable to digest solids, and, if given, they only accumulate in the intestines and upset the digestive organs. Milk, which may be combined with a few drops of saccharated lime water to prevent curdling, and meat juices, especially

Bovril and Valentine's meat juice, should be given. If possible, about four pints of milk should be given in the twenty-four hours, and about a pint and a half of strong beef tea, with a teaspoonful of Bovril or Valentine's meat juice every four hours.

The so-called "Chronic Pyæmia."—In some cases a condition occurs known as chronic pyæmia, in which acute abscesses form all over the body. This affection is not a true pyæmia, that is to say, it is not of embolic origin; it is rather a condition where the organisms are floating free in the blood and attack various weak spots throughout the body.

Treatment.—Any external abscess will of course require to be opened. Where the joints become inflamed they must be fixed by a splint, and if there be much pain they must be opened freely and a drainage tube inserted, so as to provide for the free escape of the discharge. The patient is usually not in a condition to bear any more severe procedure; besides, free drainage of the joint often suffices for recovery, leaving, no doubt, more or less stiffness behind. Whether the injection of *antistreptococcic serum* will be of use is a point which can hardly be determined in the present state of our knowledge, but it is well to bear it in mind, and as at any rate it does no harm, recourse may be had to it. For details as to dose, method of injection, etc., see p. 183.

ERYSIPELAS.

Erysipelas may be defined as a febrile disease caused by a streptococcus, and characterised by a well-defined spreading redness of the skin.

Symptoms.—The disease usually commences from four days to a week after the operation or injury, but it may occur as early as the first or the second day. There are usually certain premonitory symptoms preceding the actual attack, such as malaise, headache, loss of appetite, and a feeling of tension and pain about the wound; this may be followed by a rigor. In other cases the disease may begin suddenly with a severe rigor, without any premonitory symptoms. However the attack may be ushered in, it is followed by a rapid rise of temperature to about 104° F.; there is usually only a single rigor. Along with the rise of temperature there is headache, and there may be some nausea or vomiting, a rapid soft pulse, foul tongue, great thirst, scanty urine, diminution of the discharge from the wound, and swelling of the neighbouring lymphatic glands, to which there may be red lines running from the wound. Occasionally there is somewhat furious delirium. In from ten to twenty-four hours after the rigor a dark red or crimson blush, sharply marked off from the surrounding parts, appears around the wound, and the reddened portion is somewhat swollen. The redness increases and usually spreads along the course of the lymphatic vessels, that is to say, towards the trunk. The margin of the rash can be felt as a distinct raised ridge. Where the tissues are lax, as in the eyelids or the scrotum, the swelling may be very

great and bullæ may form upon the surface; bullæ may also appear, although not so frequently, when the trunk or limbs are affected. During the course of the disease there is often albuminuria. After six to eight days there is generally a rapid fall of the temperature which keeps high during the acute period. The constitutional phenomena disappear, the appetite improves, the redness gradually fades and usually dies away by the middle of the second week; finally desquamation occurs. This desquamation is of great importance because it is in the scales of epidermis that the chief source of the erysipelas infection is to be found. In bad cases the disease may end fatally during the second week, from pyrexia and general exhaustion.

Varieties.—This disease is fortunately very seldom seen nowadays, and the form usually met with is the mild one which ends in recovery. Formerly a number of other varieties were described, such as wandering erysipelas, where a patch of erysipelas appeared in one spot, then died away, and a fresh patch appeared elsewhere, and so on, constitutional symptoms usually showing themselves with the appearance of each fresh patch. The most serious forms of erysipelas were described as phlegmonous and gangrenous erysipelas; these were cases where, along with the symptoms already described, there was suppuration in the subcutaneous tissues, which sometimes took the form of an abscess, but more commonly manifested itself as a diffuse cellulitis; occasionally the skin sloughed together with the deeper tissues. In these cases the patient very soon passed into a typhoid state and often died.

A question much debated at the present time is, whether these gangrenous and phlegmonous varieties of erysipelas are really due solely to the erysipelas organism, or whether there is a mixed infection, the erysipelas organism growing in the skin, and the streptococcus pyogenes in the deeper structures. The point is not at all settled, the majority of investigators inclining to the opinion that the streptococcus pyogenes and the erysipelas organism are essentially one and the same, being only slightly modified in virulence; according to this theory phlegmonous erysipelas would be regarded as merely a more virulent form than the one that is commonly seen nowadays. In favour of the theory of a mixed infection is the fact that there is frequently diffuse cellulitis without cutaneous erysipelas and *vice versâ*; besides this there are points in the bacteriological history of the organisms which seem to indicate a distinct though very slight difference.

Pathology.—The streptococcus which causes the disease spreads in the cutaneous lymphatic vessels, and is found in the skin immediately beyond the edge of the blush; the organisms are always a little in advance of the visible disease. At the edge of the blush the lymphatic vessels are found full not only of micrococci but also of leucocytes, while nearer the centre of the redness the micrococci have disappeared and leucocytes only are found. Erysipelas is, therefore, looked upon as one of the chief examples of phagocytosis, the phagocytes attacking and destroying the

organisms and putting a stop to their action. This view may possibly help to explain the results of treatment.

Treatment.—In the treatment of erysipelas it is needless to say that **prophylaxis** is extremely important, and as erysipelas is never met with in aseptic wounds, the best prophylactic is to secure the asepsis of all wounds.

(*a*) **General.**—The mild form usually met with nowadays generally subsides spontaneously without any special treatment. Provided there be no internal complication, such as visceral disease, it generally suffices to administer a saline purgative, such as a couple of drachms to half an ounce of sulphate of magnesia, and to see that the bowels are afterwards kept open daily with smaller doses (about a drachm) of the same drug, given in warm water the first thing in the morning. A more pleasant aperient is effervescing sulphate of soda in doses of a drachm, or an ordinary seidlitz powder. Quinine every four hours in doses of one or two grains and tincture of perchloride of iron are looked upon as being of special value; fifteen minims of the tincture of perchloride of iron may be administered in water every three hours. The diet should be fluid, and should consist of milk, beef tea, or strong soups given in fairly large quantity.

(*b*) **Local.**—Various forms of local treatment have been employed, and in the more severe forms of erysipelas it is important to make the most strenuous efforts to check the local progress of the disease. In former days a very favourite plan was to draw a line on the skin around and just beyond the area of the redness with solid *nitrate of silver*, or to paint on liniment of *iodine* in a similar manner, and, as a matter of experience, it was found that in a certain number of cases the erysipelas stopped at this line and seemed unable to cross it. At first sight this treatment does not seem very rational, but if we bear in mind what has just been said as to the relation of erysipelas to phagocytosis the treatment becomes explicable and logical. If the skin be irritated with nitrate of silver or strong iodine there will naturally be increased leucocytosis in the part, and if this be done a day or two before the erysipelas organisms reach the area to which the irritant has been applied, they will find the tissues and vessels blocked with large numbers of leucocytes, and the phagocytic action of the latter may suffice to prevent their further spread. Hence it seems probable that one reason why this method did not uniformly succeed is that the application was not always made sufficiently early or far enough away from the spreading margin to permit a sufficient accumulation of leucocytes to occur in the part before the organisms reached it. This is not a method of treatment that we are disposed to reject, provided that care be taken to apply the irritant very thoroughly at some considerable distance from the edge of the redness; in fact, the method of treatment which at the present time seems to promise best, namely Kraske's method, probably acts on this principle.

Kraske's Method consists in making numerous small scarifications in the skin at some distance beyond the spreading edge of the erysipelas,

just deeply enough to cause the vessels to bleed. These scarifications should be very numerous, and are made to cross each other and to surround the whole area of the redness, at a distance of about 2 inches from its edge (see Fig. 62); after the capillary oozing has ceased the blood is wiped away and the affected area is either soaked with a 1-20 carbolic acid solution or is sprayed with it for about an hour. After the scarification and the spraying, compresses of gauze soaked in 1-40 carbolic acid solution should be applied over the scarified surface. The result is that, partly as the result of the scarifications and partly as the result of the carbolic acid, very considerable irritation is produced all round the erysipelatous area, and, as suggested above, when the organisms reach the irritated part they are met by a barrier of cells. Certainly experience seems to show that Kraske's method is by far the most effectual plan of

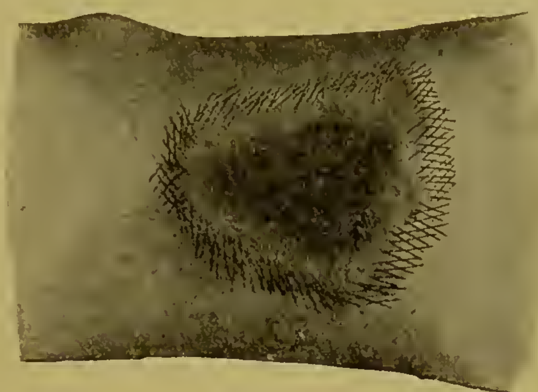

FIG. 62.—KRASKE'S METHOD OF TREATMENT FOR ERYSIPELAS. The ring of scarifications should be made, as depicted above, well clear of the margin of the rash. It is as well to allow an interval of quite two inches.

treating erysipelas, so long as the affection is a true cutaneous one, and not an inflammation of the subcutaneous tissues as well. It should however only be used in severe cases: it is painful, and necessitates the use of an anæsthetic during the scarification.

There are many applications to the actual erysipelatous part advocated by various authorities; some surgeons state that they have derived benefit by spraying it freely with *carbolic acid*, which is done upon the presumption that the acid is absorbed and, passing into the lymphatic vessels, directly affects the organisms; probably this idea has not any very good foundation in fact. In most cases applications calculated to relieve the local discomfort are sufficient. Where there is not much heat or pain, all that is necessary is to wrap the part up in salicylic wool. Where there are both pain and swelling, the use of *lead lotion* or lead and opium lotion (see p. 9) is to be recommended, lint kept constantly moist with the lotion being placed over the affected area. During desquamation it is well to keep the part anointed with some antiseptic ointment, such as the ung. eucalypti. This both relieves the troublesome itching often complained of, and lessens the chance of dissemination of the infective epidermic scales.

Treatment of Phlegmonous cases.—Where the case is one of the so-called phlegmonous or gangrenous erysipelas, the treatment must be practically that of diffuse cellulitis (see p. 29). *Free incisions* should be made into the part in all directions so as to allow the escape of the discharge, and then *constant irrigation* carried out in the manner already described (see p. 30).

Antistreptococcic Serum.—The advisability of using the antistreptococcic serum in this affection must also be borne in mind. This is only on its trial and so far the results are not very encouraging. At the same time, as it does not seem to do any harm, we are inclined, at any rate until some more definite conclusion is arrived at as to its use, to recommend that any of the forms of treatment mentioned above should be accompanied by the injection under the skin of the abdomen of a full dose of the anti-streptococcic serum. As at present supplied by the Jenner Institute of Preventive Medicine, a full dose is about 20 c.c., of the serum; a dose of half that quantity should be repeated in twelve hours, while a third dose may be given twelve hours later (see also p. 183).

TETANUS.

Definition.—Tetanus may be defined as an infective disease of wounds due to a special bacillus and characterised by painful tonic contractions of the muscles with convulsive exacerbations: it commences in the muscles of the jaw and neck, and spreads to all the voluntary muscles of the body.

Symptoms.—The affection usually begins between the fifth and fifteenth day after the infliction of the wound, and, preceding the establishment of the disease, there are often *prodromata*, such as a feeling of malaise, a tendency to yawn, headache, fear on the part of the patient that he will not get better, and neuralgic pains in the wound radiating along the nerves and accompanied by local spasms or cramps.

In a day or so after the appearance of these premonitory symptoms the typical symptoms of tetanus set in: the muscles of mastication are generally the first to be affected and this produces the condition known as *trismus*. The masticators contract and more or less fix the jaw, and on any attempt to open the mouth to eat or drink, convulsive contractions of these muscles occur. The spasm next attacks the muscles of the neck, resulting in the fixation of the head, and about the same time the muscles of expression also become affected, giving rise to the *risus sardonicus*. In this condition the angles of the mouth are drawn out, the alæ of the nose elevated, the eyes widely opened, and the forehead wrinkled. The next set of muscles affected is generally the pharyngeal group, leading to spasmodic dysphagia. Soon the voluntary muscles elsewhere are attacked, generally in groups, those next affected being usually the sacro-lumbar muscles and those of the lower extremities, leading to *opisthotonos*; then the muscles

of the upper extremity, those of the abdomen, and, fortunately last of all, the muscles of respiration. The great feature of this disease is that the muscular spasm seldom relaxes altogether, while the least movement or disturbance of the patient is very apt to set up clonic contractions,—the well-known tetanic spasms. The pulse is generally pretty rapid during the course of the disease, varying from 100 to 140. The temperature may be only slightly raised but usually it is up to 104° F., being naturally highest during the convulsions. Where the temperature goes higher than 104° or 105° the condition is generally very grave and, if the pyrexia be not reduced, the patient often dies of it. The respirations are normal but increase in frequency during the attack; the patient cannot swallow, the saliva runs out of the mouth, there is diminution in the amount of the urine, but no albuminuria, and there is profuse sweating after the convulsions.

Varieties.—Tetanus may be either acute or chronic. The **acute** form accompanied by high temperature usually ends fatally in four days, and of those affected with this form only about 1 % recover under ordinary treatment. In the more common **chronic** variety the convulsions are less frequent, and not so general, but this form may become acute and death then rapidly takes place; about 20 % of the patients recover.

Causes.—Tetanus most commonly occurs after wounds of the extremities. It is due to a bacillus which is anaërobic and spore-bearing, and which is commonly found in garden earth, in horse-dung and generally in places soiled with the latter. The reason why it occurs especially after wounds in the extremities is that they are more likely to be soiled; although lacerated wounds are those most frequently associated with tetanus, it may follow a very slight scratch. It is not the amount of laceration of a wound that is of consequence, but the soiling of it with earth. No doubt the soiling is more likely to be great where the wound is torn than where it is simply a clean incision.

Causes of Death.—The causes of death in tetanus are: (1) laryngeal spasm, (2) pressure of the trachea against the spine, in cases of bad opisthotonos, (3) spasm of the diaphragm or other respiratory muscles, (4) arrest of the heart's action either from spasm or paralysis, (5) exhaustion and inanition, and (6) hyperpyrexia.

Treatment.—**Prophylactic.**—In the treatment of tetanus prevention is naturally the first point, and as tetanus in aseptic wounds is quite unknown, it is clear that strict purification of wounds likely to be infected with the tetanus bacillus must be carried out. Hence in all cases where a wound is soiled with earth, and where lacerated wounds have occurred from falls in stables, gardens and so forth, the wound must be very thoroughly purified, a nail-brush being used to scrub away the earth, and the whole wound thoroughly sponged out with undiluted carbolic acid. For further details concerning the purification of wounds see p. 191.

Curative.—When the disease is established there is at present at our disposal the *anti-tetanic serum*, which is undoubtedly effectual in a very

considerable number of cases, and this is the first remedy that should be employed. An injection of anti-tetanic serum (which is the serum of horses, or other animals which have been rendered immune to tetanus) must be introduced in a large dose in the first instance, and must be repeated at intervals of from 12 to 24 hours, the exact amount being determined by the effect produced. It is well to begin with 20 c.c., and to repeat the dose in from 12 to 24 hours, according to its effect on the spasms. This should be again repeated every 12 or 24 hours if necessary. The effect of the serum is sometimes very remarkable, but it is not immediate, and the spasms may recur after its use so severely as to require the administration of chloroform; they usually recur, however, at longer intervals and with less severity.

Treatment of the Wound.—In the early stage also, the wound should be thoroughly cleaned out. We do not know the exact *modus operandi* of the tetanus bacillus, though it is seldom limited to the wound, but nevertheless it is well, in the first place, to give the patient chloroform, thoroughly open up the wound and wash away all the decomposing material, and then to clip away any gangrenous shreds, thoroughly sponge the wound out with pure carbolic acid, and stuff it with cyanide gauze sprinkled with iodoform. After this has been done the dressing need not, as a rule, be disturbed for two or three days, so that the patient is saved the pain and the risk of convulsions involved in attention to the wound. Amputation is frequently performed in cases of wounds of the extremities, but, as the disease has generally established itself in the system, the operation is, as a rule, quite useless, and may be hurtful from the pain and disturbance it causes. If anything at all is to be effected by local treatment, as much will be done by thorough disinfection of the wound as by amputation, and this with much less risk to the patient.

Drugs.—Whether the serum be injected or not, it is necessary to administer sedatives, and the one most in vogue is *chloral.* It should be given in large doses, so that in the course of 24 hours an adult shall have as much as 150 or even 200 grains. Care must of course be taken not to poison the patient with the drug, as has undoubtedly happened in some cases, but usually the amount mentioned can be administered in the course of 24 hours without risk. When there is inability to swallow, the drug may be administered by the rectum. Bearing in mind also the fact that the slightest noise or disturbance is very likely to bring on a spasm, the patient should be completely isolated. He should be placed in a room which is thickly carpeted, and complete silence should be maintained, and it is well to wrap up all the exposed portions of the body in cotton wool, so as to avoid any irritation to the surface of the skin from the impact of cold air, etc.

When the spasms are very severe and threaten, for example, either to produce a condition of dangerous hyperpyrexia, or to cause death from obstruction to the respiration, *chloroform* should be at once administered.

When the patient is under the influence of the anæsthetic, the spasm rapidly subsides, and repeated administrations may be called for in bad cases. When the patient is unable to swallow, advantage should be taken of the administration of the anæsthetic to introduce suitable nourishment into the stomach by means of a stomach tube; the opportunity may also be taken to give a nutrient enema. *Morphine*, in doses of $\frac{1}{6}$th of a grain subcutaneously, may also be given every three or four hours, but among drugs the chief reliance is to be placed on chloral and chloroform. When hyperpyrexia occurs the temperature should be reduced by sponging with tepid water (see p. 215) or by cold wet packing. The former is preferable, as cold water is very apt to set up a spasm. Should sponging fail to reduce the temperature it may however be necessary to have recourse to wet packing, which is done as follows. A mackintosh is put under the patient who is then wrapped up in a sheet wrung out of iced water. A blanket is thrown over him and he is left in the wet pack for from five to fifteen minutes. At the end of this time the sheet and the mackintosh are removed, and the patient is carefully dried and covered with the bedclothes.

Diet.—As far as possible the strength should be kept up by proper nourishment; indeed, this is a most essential part of the treatment, and the great majority of cases where the patient cannot swallow end fatally. Stimulants may also be necessary towards the end of the disease. If the patient cannot swallow, and especially if the attempts to do so produce convulsions, it is necessary to resort to rectal feeding; great care must, however, be taken to disturb the patient as little as possible in introducing the food into the rectum. For this purpose zyminised suppositories are of great value; one should be introduced every four hours, and every two hours after the suppository a beef-tea enema should be given. The enema should be small, about two ounces of Bovril at a time being sufficient; it is best to peptonise it before it is introduced (see p. 83). Later on in the disease, when the patient is becoming exhausted, it may be necessary to administer stimulants along with the beef-tea enemata. Watch should be kept to see that the urine is passed, for the bladder is very apt to become distended, and from time to time of course the bowels should be washed out with an injection of warm water. Above all things, care should be taken to avoid all sudden movements, and to be as gentle in manipulating the patient as possible.

CHAPTER XI.

AFFECTIONS OF CICATRICES.

CHELOID.

While in cases in which union by first intention has occurred, the cicatrix is usually healthy, this is not invariably the case, and when the wound is large and has been allowed to heal by granulation, the scar left is very often unsatisfactory. In either case the affection known as **false cheloid** or thickened cicatrix may be met with in certain patients. In this condition the cicatrix becomes much thickened, and raised above the surface of the surrounding skin; where the scar is linear there is a hard raised bar of this cheloid material, corresponding to the line of incision, and where it is a broad one the affection generally begins along the line of junction of the skin and the cicatricial tissue, and spreads thence throughout the rest of the scar. Where the scar is broad a most unsightly deformity is produced as the surrounding parts are pulled upon and puckered up. The scar does not yield as ordinary scar tissue should, and the cheloid itself is painful, and is liable to become ulcerated.

Causes.—The cause of this condition is by no means clear. It would appear that there is a special tendency for it to affect scars in those who are or have been the subjects of tuberculous disease, but it also occurs in those in whom there is no such tendency, and in them it is not uncommon to find that every scar—even down to a pin- or needle-prick—will harden and become cheloid. As regards the nature of this thickening, the microscope reveals simply a large number of young cells and granulation tissue.

Cheloid scars, especially if quite small, sometimes disappear in the course of time, but such a termination is very uncertain and cannot be confidently reckoned on.

Treatment.—The condition is one that is excessively difficult to get rid of, and, as far as our present knowledge goes, it cannot be prevented; neither can its occurrence be anticipated. When it is seen that it is about to occur, *i.e.* when the scar shows signs of thickening, the best treatment is to try to diminish the vascularity of the part. This may be done in various ways, more particularly by *pressure*, exerted either by strapping,

by the application of collodion, or by a firm bandage. Perhaps the simplest method is to paint the scar with ordinary (not flexile) collodion; as this dries it contracts, and by compressing the small vessels diminishes the blood supply of the scar. This method is strongly to be recommended in the early stage; but it is not likely to do so much good when the cheloid condition is well developed. In applying pressure of any kind it should be borne in mind that ulceration is very apt to occur in large cheloids, and even the application of collodion may sometimes precipitate the onset of the ulceration.

Cod liver oil should also be regularly administered internally, a dessert-spoonful to a tablespoonful of cod liver oil or one of its emulsions, such as Scott's or Mellin's, being given about four times a day. Some surgeons recommend *scarification* of the scar with a lancet or a fine electric cautery point, but it is doubtful whether any real permanent benefit results from this plan of treatment.

The question of the advisability of *excising* a cheloid is one which constantly arises and which has been much debated, but the great objection to the procedure is that the scar resulting from the operation will almost certainly become cheloid in its turn; this applies not only to the scar itself but also to the stitch tracks adjacent to it. When a considerable area of skin has been excised, and there is so much tension on the stitches that they cut their way through the skin for some distance, a very unsightly appearance is presented should they become cheloid. At the same time in certain cases it seems to be quite justifiable to remove the mass even at the risk of linear cheloid subsequently resulting. For example, where there is a broad ulcerating cheloid leading to much contraction and great inconvenience, it is well to excise it, so long as the skin around is sufficiently lax to allow the edges to come together without marked tension after they have been freely undermined; the old broad scar is thus converted into a linear one. In doing this it should be borne in mind that the stitch tracks will have a great tendency to become cheloid, and, therefore, if possible no sutures should be inserted through the skin; the method of buried stitches, recommended on p. 154, should be employed, deep catgut stitches being inserted, through the subcutaneous tissue only, from the points where the undermining ceases on the one side to the corresponding points on the other, so as to relieve the tension on the edges. The latter are then approximated by stitches passing through the fat and the deeper parts of the skin, the superficial margins being brought together by strips of gauze fixed on with collodion. A very narrow cicatrix is thus obtained, and should this become cheloid it is not a matter of great importance; sometimes the condition does not recur. Excision of cheloids cannot, however, be recommended when a large raw surface will be left, as, even if this be skin-grafted, the condition is apt to reappear at the edges of the grafts, and spread over the whole surface of the wound.

CONTRACTING CICATRIX.

This is a very serious condition under certain circumstances. Even cicatrices resulting from healing by first intention sometimes contract so much as to cause a good deal of interference with movement. This is very well seen where thyroid tumours have been excised by vertical incisions in the middle line of the neck; if the cicatrix contracts to any extent, a band is formed between the sternum and the trachea which interferes with the due extension of the head upon the trunk and often causes much inconvenience.

Treatment.—In cases such as the above, the cicatrix should be divided transversely about its centre, the skin and cicatricial tissue undermined, and the divided ends of the scar pulled well asunder. It is then generally possible to bring together the lateral angles of the lozenge-shaped incision thus produced and so to convert the transverse into a longitudinal wound, which is then stitched up and the scar thus elongated. In cases where, after burns, the surgeon has to do with a very large cicatrix, all tense bands should be divided in this manner, and the raw surface left after separation of the ends of the cicatrix should be grafted upon at once; owing to the extent of the affected area it will not be possible to suture it in the manner just described. There are many other methods of dealing with the deformities caused by cicatrices in special situations which will be discussed under their proper headings.

PAINFUL CICATRIX.

Cicatrices are sometimes met with which are intensely tender, so that the slightest touch causes exquisite pain, which is usually neuralgic in character, and radiates from the scar. These painful scars most commonly occur when the edges of a wound have not been brought accurately together, but they may be met with even where healing by first intention has occurred, and they indicate the implication of nerves in the contracting fibrous tissue of the scar.

Treatment.—The only satisfactory treatment in these cases is to dissect out the scar, cutting well into the healthy tissues at the sides, so as to remove not only the entangled nerve ends which may have already become bulbous, but also the adjacent and probably inflamed portions. When there is a broad scar and the edges of the wound cannot be brought together after excision, skin-grafting (see p. 50) or some suitable plastic operation is indicated.

ADHERENT CICATRIX.

A scar may be adherent to the tissues beneath, and may thus become a source of great trouble to the patient; besides which, these scars are often

weak and readily ulcerate. For example, in the case of a sore over the tibia, the scar may become fixed to the bone, and is then very liable to break down and ulcerate after comparatively slight injuries which would not affect it were it freely moveable. The same is also the case with scars over the ends of bones after amputation. Should they become adherent to the bone, the amount of discomfort and pain which they cause is extreme, and, as will be pointed out in dealing with amputations, it is one of the essentials of a good stump that the scar should not be adherent to the end of the bone.

Treatment.—In cases of adherent cicatrix after amputation, the obvious remedy is to open up the flaps, release the adhesions, and, if necessary, remove a slice of the bone. In other cases, where the surgeon has to do with a scar adherent to such structures as bones, tendons or muscles, an attempt may be made, where the adhesion is slight, to divide it by a tenotomy knife introduced through the skin at the margin of the scar. Generally, however, it is best to dissect out the scar altogether, and then, by means of a plastic operation, to turn in a flap from the side so as to cover the raw surface thus made; the surface from which the flap is taken may be skin-grafted (see p. 50) if its edges cannot be brought together. This is preferable to grafting directly over bone, to which the grafts might in their turn become adherent. In some of these cases it has been suggested that portions of the underlying bone should be removed, so as to shorten the limb and to relieve the tension on the wound left after excision of the scar, so that its edges can be brought together. Although this operation has been more than once practised, it can, however, only be called for in extreme cases; in the large majority the method just described will suffice.

EPITHELIOMA.

Another reason for getting rid of scars which form adhesions to the deeper parts, or those which are constantly in a state of irritation, is that, as the patient gets older, such scars are very apt to become the seat of malignant growths, more particularly epithelioma. Perhaps the most common seat of epitheliomata in the extremities is an old adherent scar, round the orifice of a sinus, etc., and this is a point which should be carefully borne in mind in treating these conditions.

Treatment.—The treatment of epithelioma affecting scars is the same as the treatment of the disease elsewhere, namely free excision of the diseased area and examination, and, if necessary, excision of the nearest lymphatic glands. The exact nature of the operation will depend upon the situation and extent of the disease, but there should be no hesitation in removing it very freely, even by amputation if necessary. Recurrence is less frequent after operation for epithelioma in the extremities than elsewhere, and this is partly due to the fact that there is plenty of room for wide removal of the disease.

CHAPTER XII.

SYPHILIS.

Syphilis is an infective disease, probably of a bacillary nature, which has a period of incubation and a more or less regular succession of symptoms. The disease may be *acquired*, usually as the result of impure sexual connection, or it may be inherited; in the latter case it is called *congenital*. It is generally divided into three stages or periods.

ACQUIRED SYPHILIS.

Primary Stage.—The first manifestation of acquired syphilis appears as an induration at the seat of innoculation, commonly termed a "hard" or "Hunterian" chancre, which generally undergoes ulceration. This induration arises at any time from ten days to eight weeks after infection: it most commonly occurs about the fourth week. It is followed, first by enlargement of the nearest lymphatic glands, and subsequently of those in other parts of the body. The induration at the seat of innoculation, and the enlargement of the nearest lymphatic glands are the phenomena usually included under the term "Primary Syphilis."

Secondary Stage.—Following the primary condition, and usually commencing within three months after infection, a series of inflammatory phenomena affect the skin, mucous membranes, fibrous tissues, periosteum, etc., and these phenomena appear at intervals and are spread over a period of time, the length of which varies with the severity of the attack, but which roughly speaking lasts about two years. The early phenomena are usually the mildest and the most superficial, but, as time goes on, the lesions become of a severer type and are more deeply seated. During this period, which is spoken of as that of "Secondary Syphilis," are seen such affections as erythematous, papular, squamous, pustular, and nodular or tuberculated syphilides on the skin, and the occurrence of mucous patches or condylomata on the skin or mucous membranes. There is also frequently alopecia, due either to simple mal-nutrition of the hair caused by syphilis, or resulting from pustular syphilides of the scalp; in the

former case it is temporary, the hair growing again as the patient recovers, in the latter, the loss of hair is permanent. Periostitis may also occur and if left untreated may lead to permanent bony formations or nodes. Iritis and other rarer affections are also met with in the secondary period.

Tertiary Stage.—Following the secondary stage, there are other phenomena which are spoken of as lesions of "Tertiary Syphilis"; these may follow immediately upon those of the secondary stage or they may occur before the latter reaches its termination. Usually however they do not appear until a considerable interval has elapsed, the patient having enjoyed in the meanwhile many years of apparently perfect health. They take the form principally of gummata or fibrosis in the various tissues and organs of the body, or obstinate ulcerations of the skin or mucous membranes.

These remarks will suffice to define the disease, but it must not be forgotten that during the course of syphilis the general health is often markedly affected, and this is more especially the case during the early secondary period, when the patient becomes pale, weak and cachectic and the red blood corpuscles are diminished in number and lose a considerable proportion of their hæmoglobin. At this stage too there is often marked pyrexia.

Treatment.—The treatment of the various lesions in the different tissues and organs will be dealt with, in so far as they call for special treatment, when we come to deal with affections of the particular organ or tissue. Here we shall only refer to the treatment of syphilis in general.

Prophylaxis.—From this point of view it is well to enumerate some of the chief sources and modes of contagion of syphilis; the prophylaxis will obviously consist in avoiding them. The most common source of infection is perhaps the secretion from the primary sore, but a very potent factor in the spread of the disease is the discharge from secondary lesions, such as mucous papules and condylomata; the blood also is infective during the secondary stage, and this infectivity is at its height when syphilitic manifestations are actually present. The usual mode of contagion is of course by sexual connection. Kissing is also a means of spreading the disease where secondary symptoms are present in the mouth or throat; in suckling also, infection may be conveyed from child to nurse or *vice versâ*; simple sores may also become inoculated, as occurs frequently on the fingers of medical men; in the Jewish rite of circumcision a similar accident has occurred. Infection may also be conveyed by vaccination, should the blood of a syphilitic infant by chance contaminate the vaccine lymph; lastly, it may be communicated by the employment of infected utensils, such as cups, spoons, pipes, toys, etc., which have been used by those suffering from the secondary stage of the disease.

In considering the treatment of syphilis we shall discuss it in relation to the three clinical stages of the disease, namely, primary, secondary, and

tertiary syphilis. It is interesting to note that, although the division between secondary and tertiary syphilis, more particularly in respect to the time limit, is somewhat arbitrary, a further justification for this division is found in the fact that the two drugs which exercise a specific influence on the disease, namely, mercurial preparations and the iodides (especially those of potassium and sodium), act differently in these two stages. During the early secondary stage the iodides have little or no effect in causing the disappearance of the lesions, while mercury acts much more effectually. During the tertiary stage, on the other hand, the iodides are much more rapid in their action than is mercury.

Primary Syphilis.—(*a*) **Local Treatment.**—Here attention must be chiefly directed to the local treatment of the sore. In the first place, care must be taken to avoid the use of irritating applications; they only lead to enlargement of the sore and absorption of a still larger dose of the poison. No attempt should be made to destroy the chancre by caustics: they never cause the disease to abort, and only serve to produce extension of the ulceration. Excision of chancres is also not to be recommended. In the great majority of cases, by the time the diagnosis can be made with certainty, the infection has spread far beyond the seat of inoculation, and there is no chance of cutting short the disease by removing the sore. During the early period, *while the diagnosis is still uncertain*, absolute cleanliness, frequent washing with water or boracic lotion and the application of a weak boracic ointment ($\frac{1}{4}$ strength) or boracic lint, should be relied upon. *When the diagnosis is certain*, it is well to employ mercurials locally and the favourite application is weak lotio nigra (3 grains of calomel to the ounce of lime water) with which the sore is washed three or four times daily, after which a piece of lint soaked in the lotion is applied over its surface. The penis, if that be the part affected, should be kept in a bag made by sewing boracic or salicylic wool between two layers of gauze: this prevents friction and avoids soiling of the linen. *Where the sore is large and extending* it is well after drying the sore to dust it over with calomel and starch (calomel one part, starch powder three parts), two or three times a day; where sloughing is taking place or where the discharge is offensive, one part of iodoform may be added to this. Lint dipped in lotio nigra is then applied as before to the surface of the ulcer. When the chancre begins to heal, it is well to abandon the local use of mercurials and to return to the boracic lotion and weak boracic ointment.

In the case of the acutely spreading, so-called **phagedenic chancre** it is well to bring the patient rapidly under the influence of mercury, especially if the chancre be situated where its spread may do serious harm; this should be in addition to the local use of the calomel, starch and iodoform powder. These so-called phagedenic chancres, although not true phagedena, are nevertheless often due to a mixed infection, and the rule as to the use of caustics may be relaxed here. When sloughing actively progresses in

spite of the above treatment, it is advisable to scrape the surface of the sore freely, so as to remove all the sloughs, and then to apply undiluted carbolic acid to the raw surface; this may be followed by dusting with calomel and iodoform, and the internal administration of mercury as before. When the sore is small, the scraping may be done with a small sharp spoon, after application of a 20 per cent. solution of cocaine to the ulcerated surface. If it be large, a general anæsthetic, such as nitrous oxide, may be required.

(*b*) **General Treatment.**—A much debated question in the treatment of primary syphilis is whether at this stage *mercury* should be given internally or whether it should be withheld until secondary symptoms make their appearance. In this country many surgeons commence mercurial treatment directly the diagnosis is made, but abroad most of the leading syphilographers condemn the use of mercury in syphilis before the appearance of secondary symptoms, unless under special circumstances, and with this view we are in the main disposed to agree. The reasons given are that the administration of full doses of mercury at this stage has a depressing effect upon the patient, so that, when it is required for the treatment of secondary symptoms, it cannot be pushed as far as is desirable: and also that the diagnosis of a syphilitic chancre is seldom beyond the possibility of a mistake, and the patient may thus be salivated or submitted to a tedious and prolonged course of mercury unnecessarily. In certain cases, however, it is advisable to administer mercury during the primary stage, so as to produce its full physiological action. This is called for in the rapidly spreading chancres referred to above, and also in those situated where the loss of tissue they cause may do serious harm, as for example upon the eyelid; in married people and in the case of chancres on doctors' fingers it is advisable to employ it so as to avoid the risk of infecting others. According to some, it should be employed in the case of women infected during pregnancy. Where patients are extremely nervous and frightened, it is also well to give mercury in small doses during the primary stage, but not necessarily in sufficient quantity to produce its physiological effects.

During the primary stage the use of iron is of great value, and one of the best preparations is Blaud's, given in doses of 5 to 10 grains three times daily immediately after food; it is best administered in the form of capsules or cachets. Benefit is often experienced in very cachectic subjects from the use of Easton's syrup two or three times a day, in doses of half a drachm in a wineglassful of water.

Secondary Syphilis.—(*a*) **General Treatment.**—In the treatment of the secondary stage the principal drug employed is *mercury*, and the chief points to be considered are in connection with its administration. During the secondary period, whilst mercury is being taken, the following points should be attended to. (1) The diet should be carefully ordered, only plain and nourishing food being taken, whilst all indigestible matters, spices and condiments should be avoided.

(2) As far as possible, alcohol should be given up, but where patients are accustomed to take it regularly, a small amount, preferably light claret, may be allowed.

(3) Regular exercise should be taken, but the more violent forms, such as football, hunting, and the like, must be avoided, as otherwise greater quantities of mercury will be required to bring the patient properly under its influence. It has long been recognised that all persons taking mercury are particularly prone to catarrhs which are apt to be of a severe type.

(4) The care of the teeth is of the highest importance. If tartar be allowed to accumulate on them, salivation may occur before the patient is fully under the influence of the drug, and there may be considerable difficulty in continuing the mercury, on account of the premature tenderness of the gums. The patient should be enjoined to brush the teeth frequently during the day, and if there be any tenderness, an astringent mouth-wash, such as a combination of alum and tincture of myrrh, may be usefully employed.

(5) Smoking should be prohibited, both on account of the depressing effect of tobacco and especially because the irritation of the smoke predisposes to and keeps up throat, mouth, and tongue affections.

Modes of Administration of Mercury.—Mercury may be administered by the mouth, by the skin, and by intra-muscular injection. Among the various preparations of the drug administered by the *mouth*, the metallic form acts best during the early stages, and is usually given either in the form of blue pill or as a pill of hydrargyrum cum cretâ. In this stage also it is well to combine it with iron, and the following is a good formula :

℞.	Pil. hydrargyri, - - - - - -	gr. 2.
	Ferri sulphatis, - - - - -	gr. 1.
	Extract. opii, - - - - - -	gr. ¼.
	M. ft. pil. One pill to be taken thrice daily.	

"Hutchinson's formula" consists of hydrarg. c. cret. and Dover's powder in equal quantities made up into 4-grain pills, one of which is taken four times a day. The amount of Dover's powder should be varied according to the action of the mercury upon the bowels. The quantity of mercury in the pill may be gradually increased, so long as no intestinal irritation is produced, and the full doses are pushed until the mercury begins to manifest its physiological effects, as shown by salivation or soreness of the gums. When this stage is reached, the dose should be reduced, or if the tenderness of the gums be extreme, the drug may be discontinued entirely for two or three days until the tenderness has passed off, when it may be resumed in smaller doses. It should not be discontinued altogether when the physiological effects manifest themselves ; as a rule the secondary phenomena do not disappear until the physiological action of the mercury is apparent.

At a later stage of secondary syphilis, particularly in weakly subjects, other forms of mercury often act better, and give rise to less intestinal irritation than the one just described. The green iodide of mercury, for

example, is a very useful drug; it may be given in pill form, in doses of a quarter to half a grain combined with a quarter of a grain of extract of opium, three or four times a day. In the late secondary stage, and especially where the patient is very anæmic and feeble, the French preparation known as "Gibert's syrup," is often extremely good. Each ounce of this contains $\frac{1}{12}$th of a grain of biniodide of mercury, 5 grains of iodide of potassium, syrup, and water. The longer the syphilis has lasted the better in fact is the result obtained by combining iodide of potassium with the mercury.

An important question is, *how long the mercury should be continued*, for there seems good reason to believe that, in the milder cases of syphilis at all events, an actual cure may be brought about by careful treatment, at any rate tertiary symptoms may never supervene. Everyone is agreed that the mercury should be continued in as large doses as possible without producing salivation, at least until the secondary symptoms, for which it is administered, have subsided, and for two or three weeks afterwards. Also, that when fresh symptoms appear, mercury should be again administered as before. Keyes,[1] however, has pointed out that it is well to continue the treatment with small doses of mercury (about one third of the dose required to produce the physiological action) after the symptoms have subsided. Should these recur, the full dose is again resorted to. He advises that this treatment be continued, with two or three weeks interval every six months, until the end of the secondary period, in fact for two or three years. This method is certainly a very valuable one, and we would recommend that it be followed, at any rate for a year or eighteen months.

When more rapid mercurialisation is required, it is best to employ *inunction*, and in the later stages of the secondary period iodide of potassium should be administered internally at the same time. The ointment usually selected for inunction is the ordinary unguentum hydrargyri, but the same result can be obtained with a 10 or 20 per cent. oleate of mercury combined with an equal quantity of lanoline or simple cerate; this preparation, moreover, has the advantage of not soiling the linen to such an extent as the blue ointment generally does.

Inunction should be carried out as follows. Where unguentum hydrargyri is used, a portion about the size of a hazel nut is rubbed well into the skin every night, if possible before a warm fire, and this operation should occupy from fifteen to twenty minutes. The ointment may be rubbed into any part of the body where the skin is comparatively thin, for choice into the axillæ or the groins, and it should not be rubbed into the same part on two successive nights, as otherwise considerable irritation of the skin may be caused, possibly ending in the formation of a pustular eruption. For example, the inunction should be made into one axilla on the first night, into the other the following night, whilst on the third one groin, and on the fourth, the other may be chosen; on the fifth night inunction may be employed over the abdomen, and the patient should wear the same under-

[1] Keyes, *Venereal Diseases*, 1881.

linen and should not have a bath during these five days. At the end of this period he should take a warm bath, and then commence again and go on in this way till the gums become tender, which will usually be in about six or ten days. As soon as this happens, the patient should have a warm bath, put on clean linen, stop the inunction, and substitute for it the internal use of mercurials, such as 2-grain doses of pil. hydrargyri combined with extract of opium, three or four times daily, as already detailed (see p. 232). If, under this treatment, the condition of the gums gets worse, the dose of pil. hydrargyri should be reduced; if, on the other hand, it improves, the dose may be slightly increased, and should be continued till the eruption disappears, and for two or three weeks afterwards, when it may be reduced to one half or one third of the amount; this must be continued for a considerable time, as has already been mentioned (see p. 233).

Another method by which mercury can be introduced into the system through the skin is by *fumigation*, the drug employed for the purpose being calomel. Fumigation is performed by means of a vapour bath which is best taken at bed-time. About thirty grains of calomel are placed in a small metal dish which is surrounded by another containing a little boiling water, and the whole is placed over a spirit-lamp. This vaporizing apparatus is put under the seat of a cane chair, upon which the patient, divested of his clothes, sits surrounded by a blanket reaching to the floor, and tucked tightly round the neck so as to prevent the escape of the calomel vapour. It takes about twenty minutes for the calomel to be volatilized, and the patient sits meanwhile in a profuse perspiration, so that the drug is readily absorbed through the skin. After the sitting, the patient is wrapped in a blanket and goes to bed. About twice a week is generally sufficient for the baths, especially if the patient be at all weakly, but where it is necessary to get him rapidly under the influence of mercury one may be given every night. This method of treatment is especially useful for obstinate skin affections, but otherwise it is seldom employed: the smell of the vaporizing calomel is very penetrating and offensive.

Lastly, there is the method of administration by *intra-muscular injection.* This is a very satisfactory plan where a speedy action is required, as for example in cases of rapidly spreading malignant syphilis, and it is also very useful in alcoholics, who get intestinal catarrh very readily when the drug is given by the mouth, so that there is imperfect absorption from the alimentary canal. The drug employed for injection is either the biniodide of mercury ($\frac{1}{6}$th to $\frac{1}{2}$ of a grain) dissolved in water, or the bichloride ($\frac{1}{8}$th of a grain) with a little glycerine and water added. The injections should be made two or three times a week or, if there be great urgency, every day. A fresh place should be chosen on each occasion because a painful lump frequently forms at the seat of injection. Furthermore, the injection should be made into a muscle, preferably into that of the buttock. A largish needle should be used, and its strength must be

tested carefully each time before use, because it very quickly becomes eroded and might break off in the tissues. The skin should be disinfected by rubbing it first with absolute alcohol and then with 1-20 carbolic acid, and the needle should be rapidly inserted deeply at right angles to the skin, care being taken that when this is done the patient does not start, as otherwise the contraction of the glutei may break the needle. If the muscle be firmly pressed upon around the area of injection it will tend to prevent any sudden contraction when the needle enters. The treatment is continued until the gums become tender, and then Keyes' method (see p. 233) may be resorted to, the injections being resumed if any fresh symptoms make their appearance.

(*b*) **Local Treatment** in secondary syphilis is usually of considerable benefit; the eruptions are often favourably affected by the local application of mercury in one of its different forms. Eruptions on the face may often be made to disappear quickly by the use of emplastrum hydrargyri, the patient being meanwhile treated constitutionally by one or other of the methods already described. The plaster should be renewed every night; it may be usefully employed also in cases of skin eruptions elsewhere.

Condylomata and mucous patches also disappear very rapidly where local treatment is combined with the internal administration of mercury. They should be washed night and morning, dried and dusted over with a powder consisting of one part of calomel and three parts of starch.

Tertiary Syphilis.—(*a*) **General treatment.** During this stage the lesions will be removed much more rapidly by means of *iodide of potassium* than by mercury. We usually begin with fifteen grains of the iodide of potassium three times a day, and if this does not suffice to influence the lesions rapidly, the dose may be increased up to thirty or forty grains. The iodide should be taken from half an hour to an hour after meals, and it is well to give it with tincture of orange peel or syrup of cinchona in order to avoid griping. Some patients cannot take iodide of potassium; and if it be administered they at once suffer severely from coryza, pustular eruptions on the skin, pains in the bones, etc. In such cases the sodium or strontium salt may be substituted for that of potassium, but if these cannot be borne resort must immediately be had to mercurial inunction or intra-muscular injections. It is a curious fact that patients suffer less from the physiological action of iodide of potassium in large than in small doses, and, before giving up the drug entirely, one or two large doses at any rate should be tried.

In ordering iodide of potassium for tertiary syphilis it must be remembered that its action is only to cause disappearance of the syphilitic lesions and that it has no permanent curative effect. In most cases, therefore, it is well, especially in syphilis of important organs, such as the brain, the liver, etc., to give the patient a mercurial course, either by the mouth or by inunction, at the same time that he is being treated with the iodide of potassium. After the gums have become affected the mercury may be given up.

(*b*) **Local treatment.** As in the secondary lesions, the local application

of mercury, especially in the form of emplastrum hydrargyri, is often very beneficial in the tertiary period. In very obstinate cases, and particularly in tertiary bone lesions, much advantage may be gained by excising and scraping away the gummatous material in the same way as tuberculous tissue is treated, but in most instances the lesions rapidly disappear when iodide of potassium and mercury are administered.[1]

Sulphur Baths and Spas are much in vogue in the treatment of syphilis, and a visit to one or other of them, more particularly Aix-la-Chapelle, is very much in fashion. These waters however have no specific effect on syphilis, and the benefit derived from a visit to Aix is due essentially to the careful antisyphilitic treatment carried out there by the medical men, and to the fact that the patient gives himself up entirely to the treatment. No doubt the hot baths help the action of the antisyphilitic remedies to a certain extent, and some of the benefit is also due to the complete rest and absence of worry. It is a very good thing to send a nervous, overworked business man with an obstinate syphilitic affection to Aix, Wildbad or some similar place, but, in the case of patients of moderate or limited means, it would be wrong to put them to the expense of going there, seeing that there is no specific advantage to be derived. The best time for a visit to Aix-la-Chapelle is May or June but it is open all the year round.

HEREDITARY SYPHILIS.

In inherited syphilis where the child is born alive and apparently healthy, the lesions are very much the same as the secondary and tertiary ones in the acquired form, but they are apt to be more mixed in character, and tertiary lesions may occur quite early.

Treatment.—The treatment of hereditary syphilis is essentially the same as that of the acquired form, namely, the use of mercury in the early lesions, and of iodide of potassium, with or without mercury, in the later forms. Mercury is best administered to infants by means of inunction, as by this means irritation of the stomach and interference with the feeding of the child are entirely avoided. One of the most convenient ways is to spread some unguentum hydrargyri (a piece about the size of a small hazel nut) upon the binder, leaving it to the natural wriggling movements of the child to rub the mercury thoroughly into the skin. The binder is removed every day, the skin well washed, and fresh ointment applied. Should there be any irritation of the skin, a small quantity (about ten grains) of the 10 per cent. oleate of mercury can be rubbed into the legs and arms in place of the abdominal inunction. As soon as the symptoms begin to improve, the quantity used should be diminished, but mercurial treatment should be gone on with, either in the form of mild inunctions or by internal administration, at any rate for the first year after birth. If internal administration of mercury be preferred, $\frac{1}{6}$th of a grain of hydrarg. cum cret., or $\frac{1}{100}$th

[1] See *Brit. Med. Journ.*, 1897, Vol. 2, p. 1571.

of a grain of bichloride of mercury well diluted may be given three or four times a day. The hydrarg. cum cret. may usefully be combined with bicarbonate of soda in the proportion of one grain of the former to five of the latter; one grain of this is given three or four times a day to an infant. The bichloride of mercury may be given in the form of liq. hydrag. perchlor. flavoured with aq. anethi or aq. chloroformi. At the same time it is of the greatest importance to attend to the proper feeding of the child.

In prescribing iodide of potassium, the dose will vary with the child's age. Dr. Lauder Brunton's plan of calculating the dose for different ages is very simple and efficacious. He takes the age for the full adult dose as 25, and reckons the age of the child at its next birthday as an integral part of that number; the full adult age is used as the denominator, and the child's age thus reckoned is used as the numerator. Thus, the dose for a child in the first year of life would be $\frac{1}{25}$th of the adult dose, that for a child one year old, $\frac{2}{25}$ths of the adult dose, and so on. Where the syphilis has not appeared, or at any rate has not been treated with mercury, in infancy, it is well to employ mercurial inunction in addition to the iodide of potassium which will be required in the later manifestations of the disease.

CHAPTER XIII.

CHANCROID, OR SOFT SORE.

Definition.—Chancroid is an infective ulceration due to a bacterium, and generally occurs on the prepuce or glans penis. The affection is locally inoculable, and frequently leads to infection of the neighbouring glands, but general infection never follows.

Symptoms.—As the result of infection there is a local sore which begins as a pimple a few hours after inoculation, rapidly enlarges and ulcerates, and gives rise to other sores in its vicinity. These extend rapidly, and may cause considerable loss of substance; when on the frenum they may perforate or destroy it; when beneath the prepuce they may give rise to a good deal of œdema and phimosis or paraphimosis; and where no attention is paid to cleanliness they are apt to lead to sloughing and a condition of phagedena.

The inguinal glands very quickly become infected, and the glands nearest the genitals enlarge and often suppurate; suppuration may occur in one gland after another, so that the affection may be a long and tedious one. When these abscesses are opened or burst spontaneously, the skin is frequently found to be undermined for a considerable distance; extensive chancroid ulceration may occur in the groin, which takes a long time to heal, and which may cause widespread destruction of tissue. The organism causing the chancroid ulceration is said to be purely aërobic; a fact that may explain the extensive and rapidly spreading ulceration that so often occurs after these abscesses have burst or have been simply incised.

Treatment.—When we bear in mind the serious results that may follow chancroids, and the length of time that the patient may be laid up and unable to follow his occupation, it is evidently very important to endeavour to cut short the disease at as early a stage as possible.

Local Treatment.—Hence, as soon as the diagnosis is made (and the chief point is to distinguish chancroid from herpes præputialis on the one hand, and syphilis on the other), an attempt should be made to destroy the sore by caustics, of which the best is probably nitric acid. In applying caustics care must be taken to prevent fresh infection of the surface, and they should never be employed unless the sores can be readily exposed.

(*a*) **Where there is no Phimosis.**—In sores under the prepuce where the latter is not œdematous and can be readily retracted, the prepuce should be pulled back and the whole exposed surface thoroughly washed with a 1-20 carbolic lotion and subsequently with a 1-2000 sublimate, especial attention being paid to the thorough cleansing of the sulcus behind the corona glandis. The sores should then be dried carefully and a 10 per cent. solution of cocaine applied to their surfaces. After a few minutes this is wiped off, and then the nitric acid is applied either by means of a rod or brush of glass, or, failing that, with a small piece of wood, such as a match. The surface and edges of the sore are thoroughly mopped with the acid and great care must be taken not to let it run over the neighbouring mucous membrane. After allowing the acid to soak into the tissues for five minutes or so, any excess is neutralised by plunging the end of the penis into a saturated solution of carbonate of soda till effervescence entirely ceases. The parts should next be thoroughly washed with warm sublimate solution, and powdered thickly over with iodoform, outside which is applied boracic lint dipped in warm boracic lotion; the prepuce is then pulled forward over the lint so as to keep it in position. The prepuce should be retracted three or four times daily, the parts bathed in a warm 1-2000 sublimate solution, the boracic lint carefully removed and at once burnt, and a fresh piece applied. As the sores heal, the lint need not be changed so often. When granulation is complete, the iodoform and lint may be abandoned, and ¼ strength boracic ointment substituted, until healing is complete. The same treatment should be adopted in cases where the sores are situated on the glans penis.

(*b*) **Where there is Phimosis.**—Where the prepuce is œdematous and cannot be retracted, there should be no hesitation in slitting it up so as to get free access to the sores. In the first place an anæsthetic is given, and the parts beneath the prepuce are syringed out as thoroughly as possible with warm 1-2000 sublimate solution. The prepuce is then slit up along the middle line upon its dorsal surface so that the glans can be thoroughly exposed; this may be done by thrusting a curved bistoury beneath it or by introducing one blade of a pair of blunt-pointed scissors between the glans and the prepuce. The parts are thus fully exposed and are then washed with the strong mixture, and subsequently with a 1-2000 sublimate solution and the sores thoroughly cauterised in the manner just described, powdered with iodoform and dressed with wet boracic lint. As the latter very readily dries up, it is as well to put a piece of guttapercha tissue outside it and to keep the penis in a boracic bag (see p. 230). Iodoform is objectionable on account of its smell, and, therefore, as soon as the sore begins to assume a healthy appearance, its use may be discontinued.

Phagedenic sores should also be treated by cauterisation, and especial care must be paid to cleanliness, and if, as the slough separates, portions of the sore show fresh signs of infection, they should again be destroyed.

The cauterisation may be effected in the milder cases by means of nitric acid; if, however, the affection be extensive and spreading rapidly, the actual cautery may be necessary. The destruction of the affected parts must be carried out boldly; the best plan is to put the patient under an anæsthetic, clip away all sloughs and undermined skin, and then cauterise the whole area thoroughly, going quite wide of the disease both in its superficial area and in depth (see also p. 59). The after-treatment is the same as that just described.

General Treatment.—The patient must have nutritious diet, and should rest as much as possible, so as to avoid irritation of the inguinal glands. Certainly all violent exercise, such as games, prolonged standing, bicycling, etc., should be strictly prohibited. In the severer cases, rigid confinement to bed, with the administration of quinine and diffusible stimulants are absolutely necessary. The bowels should be kept acting regularly.

Treatment of Inflamed Glands.—As soon as signs of inflammation of the inguinal glands become evident, the patient should be put to bed and warm fomentations applied to the groins; if the primary sores are doing well, it not uncommonly happens that the glandular inflammation subsides. We do not advise the peri- and intra-glandular injection of carbolic acid and other substances advocated by some surgeons, as they are painful and generally inefficient. Most careful watch should however be kept and, if it become evident that suppuration is occurring, *excision* of the mass of glands and the abscess in them should be at once resorted to. By this means much time is saved, and a long illness avoided, for if these abscesses are once allowed to open spontaneously, the surface may become chancroid and healing is then very slow and is often further delayed by the formation of fresh abscesses in the neighbouring glands. This can be avoided by making, in the first instance, a clean sweep of the affected glands and the neighbouring tissues. It is not sufficient to simply shell out the enlarged glands, because the peri-glandular tissue very soon becomes affected and suppuration may occur in it. Care should also be taken to cut wide of any abscess that may have already formed.

After the skin has been thoroughly shaved and disinfected, a free incision is made over the mass, and then the knife is carried through the healthy fat at some distance from the glands and, after a little dissection, the whole mass is lifted out; should the skin be adherent, the infiltrated area is enclosed in an oval incision and removed with the glands. After an operation of this kind it is well to insert a drainage tube at the outer angle of the wound and to retain it for a few days in case any infection of the operation-wound has occurred.

Sometimes, however, the case is not seen until a large abscess is present, and then the surgeon must content himself with making a small opening into it, inserting through this a small sharp spoon, scraping the wall of the

cavity thoroughly, and washing it out. Some iodoform emulsion (see p. 249) should be injected and a small strand of horsehair or a shred of gauze laid between the edges of the wound, so as to allow of the escape of the discharge, and then outside the first few layers of the cyanide gauze dressing, firm pressure is made, either by sponges or a pad of gauze or salicylic wool kept in place by a spica bandage reinforced by elastic webbing (see p. 170); this obliterates the abscess cavity by bringing its walls well into contact everywhere. This is important, since the organism being aërobic, it is thus deprived of its due supply of air much more effectually than if a drainage tube were inserted; its growth is therefore much more readily brought to a stand still. Great care must be taken in the antiseptic management of these cases, and the drain must not be left out until suppuration has entirely ceased.

Where the abscess has burst and a chancroid surface is left, the skin around must be purified and the surface of the sore cauterised with nitric acid in a manner similar to that described for the primary sore. Afterwards cyanide gauze dressings and wool should be used until the ulcer has become healthy and superficial, when weak boracic ointment may be substituted.

CHAPTER XIV.

TUBERCULOSIS.

Definition.—Tuberculosis is an infective disease, due to the growth of the tubercle bacillus in the tissues, which is characterised by the formation of nodules or tubercles tending to run together, break down and caseate, and to destroy the structures in which they are situated.

Seats.—The most frequent seat of tuberculosis is, perhaps, the lymphatic glands, more particularly those of the cervical, bronchial, and mesenteric regions. Another very common seat of the affection is the periosteum and the cancellous tissue at the ends of bones. Tuberculous lesions are also very frequently met with in the synovial membranes and in serous membranes in general, such as the peritoneum, the pleura, and the sheaths of tendons. They may also occur in various internal organs, such as the lungs, the kidneys, the prostate, etc. In fact, we may find a tuberculous lesion wherever there is connective tissue and a suitable spot for the growth of the bacillus after it has gained access to the body.

Accessory Factors.—Although the tubercle bacillus is the essential cause of tuberculosis, a number of accessory factors of great importance are concerned in the production of the disease; without their concurrence the affection, in many cases, would not occur. These accessory causes may be local or general.

(*a*) **Local.**—Among local factors *injury* plays an important part as a predisposing, and, sometimes, as an exciting cause of the tuberculous lesions; this is most frequently the case in tuberculosis of bones and joints. It is important to note that the injury must be a mild one; a severe one, such as a fracture, does not usually lead to the deposit of tubercle in the damaged part, probably because the processes of repair are then so active that the bacillus cannot cope with them. A slight injury, on the other hand, particularly one in the nature of a sprain, weakens the tissues without leading to any marked cell-exudation, and the bacilli then seem able to obtain a good footing in them. *Exposure to cold* probably also acts in this way, and, where the bacilli are already present in the body, it leads to their deposit in the part subjected to the action of the cold. Indeed, anything

which lowers the vitality and resistance of the tissues predisposes them to the attack of the tubercle bacillus.

Sepsis is also very important, not so much as an inducing cause as one which increases the activity of the disease, or at any rate interferes with its spontaneous cure. *Chronic inflammation* of a tissue seems to weaken it and to enable the bacilli to obtain a foothold, and to spread more rapidly than in healthy parts, and anything which keeps up a state of chronic inflammation may favour the development of tubercle in persons in whose bodies the bacilli are present.

There are also *certain conditions connected with the bacilli* themselves which are of great importance, the principal being the number of the organisms that gain entrance to the part. When the bacilli are few in number the risk of infection is not great, and if it does occur, the disease is generally more chronic than when they are numerous. The bacilli also vary much in virulence under different conditions, and lastly, the result depends a good deal upon whether they are free or are attached to coarser particles. Where bacilli are isolated and are present only in small numbers, they sometimes pass through the mucous membranes and become caught in the neighbouring lymphatic glands without giving rise to any primary disease at the seat of entrance; this is more especially the case in the intestinal tract and the lungs. Where, however, they are attached to coarser particles, for example, where the source from which the infection is derived is cheesy material which is not broken up very fine, then there is a local tuberculosis at the point of entrance, and from this the glandular infection may subsequently result.

(*b*) **General.**—The question of *heredity* is one of the first for consideration, and it is held by many that tuberculosis is an hereditary disease. As a matter of fact, however, there is no evidence of this heredity *per se*; what seems to be inherited is the tendency of the tissues to form a good nidus for the growth of the tubercle bacillus. This tendency may also be induced by such conditions as bad hygiene, confinement in close rooms, foul air, etc.; according to others, the same result is produced by the ingestions of foods rich in potash and deficient in sodium, such as an excessive amount of vegetables, especially potatoes.

Other factors which appear to exercise an important influence on the development of tuberculosis, although we cannot exactly say in what way they are exerted, are age and sex. Surgical tuberculous diseases occur most commonly in children before the *age* of ten, but they also occur up to old age, and from the point of view of treatment, it is important to note that, the older the patient, the less is the likelihood of a spontaneous cure. *Sex* has also a considerable influence in so far as females do not seem to be so predisposed to certain forms of tuberculosis as are males. This applies more particularly to the affections of bones and joints, and although to some extent this may be explained by the greater exposure of the male to injury, this consideration does not entirely meet the facts.

Climatic conditions are very important as accessory factors. In climates where individuals are much exposed to cold and wet, and where, moreover, they congregate in small over-heated rooms, the disease is very apt to occur, especially if one of the community has tuberculosis and thus forms a focus of infection for the rest.

Pathology.—The bacillus when introduced into the tissues leads to the formation of a microscopic collection of cells, termed a *tubercle.* These cells are epitheloid cells, which are much larger than the ordinary white corpuscles, and are probably derived from pre-existing connective-tissue cells, from the lymphatic endothelium, or even sometimes from the endothelium of the blood-vessels. Among these epitheloid cells one or more in each tubercle very often increase in size or run together, and form what are called giant cells. The subsequent history is that these tubercles increase in number until a large mass is formed; *caseation* then commences in the older tubercles, the cells gradually die, and the result is that towards the centre, or at any rate towards the older part of the mass, a cheesy material is formed; this may become encapsuled and remain quiescent, or it may give rise to a *chronic abscess.* Around the tubercles there is generally a considerable area which is not yet infected with the bacillus but which is in a state of chronic inflammation; this chronic inflammation is of great importance as an aid to the spread of the tubercles, as the latter more readily invade any structure thus affected than one that is quite healthy.

Retrogressive Changes.—The resistance of the living tissues to the growth of the organism is very considerable, so that in many cases, when the causes which facilitate the progress of the disease are removed, the bacillus is destroyed or gradually ceases to grow, and retrogressive changes then take place. These latter consist essentially in the conversion of the tubercle into *fibrous tissue* and the ultimate disappearance of the tuberculous material. In other cases, where the tuberculous tissue has undergone caseation and recovery takes place, portions of the cheesy material are absorbed whilst others are left behind and become *encapsuled* and, for the time being, quiescent, but unfortunately the bacilli or their spores seem to retain their vitality in these masses for an indefinite period. As long as the capsule around the caseous material is unbroken, and the latter is protected from the action of the cells and juices of the tissues, the bacilli seem to lie dormant, but any slight injury or some constitutional cause may very rapidly break up this encapsuled mass and lead to fresh growth of the organism and fresh infection of the part. It is, however, very important to remember that, where the conditions are favourable, the body has a very strong tendency to check the growth of the bacillus or even to overcome it altogether.

Causes inimical to them.—Various causes prevent the living tissues from destroying the tubercle, and these influences must be borne in mind so that, if present, they may be neutralised or removed. The majority

of them have already been mentioned; they are the conditions of the tissues which facilitate the growth of the bacilli, such as those produced by heredity or induced by food; careful attention to diet is therefore a very important point in treatment. Injuries not only predispose the tissues to the deposit of tubercles in the damaged part, but are also likely to increase the virulence of the disease when present. Cold, sepsis, etc., also act similarly, and further, the influence of climate and hygienic conditions are points of great importance. The relation of tuberculosis to other diseases is also of interest, for the occurrence of the latter in tuberculous patients is very apt to light up the disease or to encourage its spread. This is especially the case with regard to influenza, measles, chicken-pox, etc., and as far as possible, therefore, exposure to these diseases should be avoided.

Treatment.—In dealing with tuberculous diseases we can of course only speak here of the **General Treatment.** The local treatment must be considered in connection with the parts affected, and will be described when we come to deal with the various regions that may be the seat of the disease. Roughly speaking, we may say that the general treatment of tuberculous disease has two aims, viz.: (1) to place the body in a better condition to resist the progress of the disease, and (2) to act directly on the tuberculous process. The methods of treatment directed to the latter end consist essentially of various forms of operations, and the use of various substances supposed to exert a destructive action on the tubercle bacillus, for example Koch's tuberculin, iodoform, benzoate of soda and many others. These latter methods have more or less failed in their object, so that we cannot recommend them, while the operative and other local measures will be discussed in connection with the parts affected.

On the other hand, there are a variety of methods of general treatment which may be employed to increase the resisting power of the tissues, or to remove the causes which favour the growth of the bacillus, and these may be indicated here. An essential point is to put the patient under the best possible **hygienic conditions.** A tuberculous subject must be kept from exposure to cold and wet, which may not only induce tuberculosis in some part of the body not yet affected, but may also exaggerate an already existing lesion. He must have the maximum amount of fresh air and sunshine possible, and therefore it is very important that he should be sent where he can live a healthy out-door life. There is however no special climate suitable for all tuberculous cases. Some do better in a cold and bracing climate, others in a warm one, provided it be not relaxing. Hence all patients should not be sent to the same place, or to the same sort of climate; it is necessary to ascertain which suits the individual best. The only requisite that should be looked upon as a *sine quâ non* is that the place selected should be one where it is possible to practically be out of doors all day without danger of taking cold. When the lower extremities are unaffected care should be taken to secure a sufficient amount of

exercise; the particular form should be such that the patient runs no risk of injury, for a local deposit of tubercle is likely to occur at any spot injured. The question of *diet* is also of importance; it should be nourishing and easily digestible, and the amount of vegetables, in particular the consumption of potatoes, should be limited.

Among **drugs** there are no specifics against tuberculosis. The only point of importance with regard to them is that only those should be ordered which will increase the nutrition of the body. Of these the best seems to be *cod liver oil* which may be given pure or in the form of one of the more tasteless emulsions, such as Scott's, Mellin's or M'Kenzie's. As much of the drug should be given as is possible without disordering the digestion. As a rule it is well to begin with teaspoonful doses three or four times a day, and to increase it until it is found that the patient will not bear any more: cod liver oil should be given, however well-nourished or healthy the patient may seem to be. Children as a rule take the emulsions without any trouble. Where pure cod liver oil is used it is probably best to float it on milk. In connection with the administration of cod liver oil a method suggested by Mr. Edmund Owen for administering it to children who resent taking the oil as ordinarily prescribed, will sometimes be found of use. It consists in replacing the ordinary cottonseed oil, in which sardines are preserved, by cod liver oil (a tasteless variety for choice) and serving it on the plate with the fish. The tin is filled up from time to time with the oil, and children who are fond of sardines will often take large quantities in this manner without demur. The drug is apt to disagree with people during warm weather, and the general rule is that it should be intermitted during the summer; cream, fat bacon, olive oil, etc., should be substituted.

A drug that is very fashionable in tuberculosis, although it is questionable whether it does any good, is *syrup of the iodide of iron*, given in doses of from 15 to 25 minims three times a day, mixed with water or milk. Among other drugs, the use of iron, either in the form of tincture of perchloride of iron in 10 or 15-minim doses, or as Blaud's preparation in doses of from 3 to 10 grains, according to the age of the patient, are of value. Tincture of *nux vomica* is very useful where the appetite is bad; in fact anything that will increase the general nutrition of the patient may with advantage be administered. *Guaiacol* in doses of 1 to 5 minims is a drug which is much in vogue at the present time and which seems to be really of service.

When exercise cannot be obtained, as may happen when the situation of the disease demands absolute rest in bed, much benefit may be obtained by general *massage*. This for example may be usefully applied to the extremities when the spine is the seat of the disease, or to the upper extremity or the trunk when the lower limbs are affected, and in this way a considerable amount of exercise can be obtained; it should be combined with plenty of fresh air, which may be obtained by wheeling the patient out on a couch. By these means both the appetite and the general nutri-

tion can be well sustained. Steps must also be taken to diminish the amount of inflammation about the affected part, and where this is done the tendency to cure is greatly aided. The first essential point in this part of the treatment is absolute rest, whether the cause of unrest comes from without or within, for, apart from the presence of the tuberculous disease, movement promotes the inflammatory condition. When we come to deal with joints we shall have to lay stress upon another condition which must be attended to, namely, the tonic contraction of the muscles in the neighbourhood of the diseased joint, which leads to pressure of the inflamed articular surfaces against each other. Here, therefore, rest must be combined with extension, so as to tire out the muscles and prevent the violent pressure of the two surfaces against one another.

Various other methods may be employed to remove the chronic inflammation; these have already been referred to in full in speaking of chronic inflammation generally (see p. 17). The actual cautery, for example, is of great value in many cases of deep-seated bone and joint disease, such as disease of the spine, the hip or the shoulder joint. Pressure is also of use either combined with counter-irritation, as by Scott's dressing (see p. 21), or alone as by wrapping the joint in a large mass of wool and then applying a firm bandage over it, the bandage being prevented from slipping by rubbing into it a solution of starch or silicate. It is not necessary here to repeat the various measures for combating chronic inflammation; they are fully referred to in Chapter I.

CHRONIC ABSCESS.

Before leaving the general consideration of tuberculous diseases, we may discuss at greater length the question of chronic abscess, which is only another name for one of a tuberculous nature. In this condition an abscess forms without any of the cardinal symptoms of inflammation except the swelling. Pain may be absent or very slight, there is not necessarily any increase of the body temperature, though locally the affected area may feel a little warmer than the surrounding parts, and there is no redness of the skin over the seat of the disease, unless the skin itself be actually involved. The swelling is caused by the presence of fluid and differs entirely from the brawny swelling that is met with in acute abscesses. In fact the chronic abscess is, in the great majority of cases, simply a softening tuberculous deposit.

Briefly, the history of a chronic abscess of the subcutaneous tissue is that it begins as a small tuberculous nodule which gradually increases in size, undergoes caseation and softens in the centre. When this occurs the inflammation around becomes a little more active, and there is an effusion of fluid along with a considerable number of leucocytes into the cheesy material; the result being an investing layer of tuberculous tissue

containing fluid mixed with broken down cheesy material, disintegrated tissues and leucocytes. The essential part of a chronic abscess is the wall, and to it any curative treatment must be particularly directed. The mere evacuation of its contents will not, as in an acute abscess, necessarily lead to a subsidence of the disease. The tubercle bacilli and the tubercles themselves are present in the wall, and all that is evacuated when the abscess is incised are the broken down contents, along with the fluid and leucocytes that have passed into it as the result of the inflammation around.

Treatment.—The aim of the treatment must, therefore, be to deal with the wall of the abscess, and this is carried out in various ways according to its situation and extent.

Excision.—Where the abscess is only quite small and subcutaneous, the simplest plan of treatment is to excise the abscess wall with its contents intact, as if it were a sebaceous cyst. Similarly, where the abscess is connected with a gland, and even when it has perforated the gland capsule and spread through the fascia to the subcutaneous tissue, the only satisfactory treatment is to dissect out the wall of the abscess, and along with it, the gland from which it comes. This may be looked upon as the ideal treatment of a chronic abscess: to dissect away completely and cleanly the wall, and the focus from which it originates. Moreover, if the abscess be pointing, and has led to thinning and infection of the skin, the affected portion of the skin should also be removed. Any attempt to save it will leave tuberculous material behind, and this may act as a focus for the re-infection of the wound, so that healing may be delayed; the thin skin if left will not recover, and its death will lead to an ugly scar. Hence all adherent skin should be excised, and unless a large area be affected there is no difficulty in bringing the edges of the wound together after undermining the tissues around. When an abscess has been dissected out in this way, the wound can be stitched up completely and treated in the manner recommended for the treatment of aseptic incised wounds (see p. 152). Should the abscess wall burst during the course of dissection, and pus escape into the wound, the latter should be thoroughly and frequently douched out during the remainder of the operation; curiously enough, under these circumstances tuberculous infection of the wound does not as a rule occur. Where the abscess is connected with a gland, it is not sufficient to remove the gland which has led to the abscess; any others in the neighbourhood which are enlarged should also be taken away.

Partial Removal of Abscess Wall.—In very large deep-seated chronic abscesses it is of course impossible to remove the wall completely. Here, one of two procedures may be adopted. In the first place, if the abscess be situated so deeply that it cannot be dissected away, and if no important structures intervene between the abscess wall and the surface, the former should be laid freely open (unless it be very important to avoid causing a scar), so that the whole interior of the abscess cavity is exposed to view; as much of the wall as possible should then be dissected out and clipped

away with scissors. Any portions of wall that cannot be treated in this manner must be thoroughly scraped. The best instrument to use for this purpose is Barker's flushing spoon (see Fig. 55), by means of which a constant stream of fluid is kept flowing over the parts, so that the material loosened by the spoon is at once carried away and does not lodge in the recesses of the wound. The fluid used for this irrigation should be warm 1-4000 perchloride of mercury, and when the part has been thoroughly scraped out and the wound completely cleansed from all flakes of cheesy material and pus, a little iodoform and glycerine in the form of a 10 per cent. emulsion, made by adding 10 per cent. of sterilised iodoform[1] to glycerine, or to a 1-1000 glycerine and sublimate solution, should be poured into the wound. Two or three drachms of the emulsion, according to the size of the abscess, will suffice, provided that it be applied to the whole of the wall that has been scraped. The wound is then stitched up and pressure applied so as to bring the deeper parts together and to avoid leaving any cavity. When treated in this way, the wound in many cases heals by first intention, and there is no further trouble.

Incision and Scraping.—An alternative method is employed when the parts in front of the abscess wall prevent it from being laid freely open, as for example in the case of a psoas abscess, or when it is very necessary to avoid a large scar. Here the utmost that can be done is to make a small opening sufficient to admit the finger or the finger and a sharp spoon, and then to wash out the contents of the abscess by a weak sublimate solution of a strength of about 1-6000, or even as weak as 1-10,000. This is best done by introducing a Barker's flushing spoon into the abscess cavity and then turning the tap so that the fluid flows through it. Of course the opening in the skin must be large enough to allow of the free escape of the fluid by the side of the spoon. The latter is then pushed into all the recesses of the abscess, and when all the fluid part has been in this way evacuated, the instrument is used for scraping the wall. This is done gently but thoroughly, the whole of the wall being gone over systematically, and, in the example before us, namely a psoas abscess, special care is of course taken while scraping in the forward and inward direction, on account of the thin covering that may intervene between the instrument and the peritoneum or the iliac vein. After the abscess has been thoroughly scraped out, and all the flakes have escaped, the spoon is withdrawn, and then, before proceeding further, the cavity is wiped out with fragments of rough sponge. Pieces as large as can be forced into the cavity are used; they not only soak up the sublimate solution which remains, but, by twisting them round, their rough surface scrapes off any tags of cheesy material which still adhere, and in this way the cleansing of the cavity is completed. About half an ounce to an ounce of the sterilised iodoform and glycerine emulsion referred to above is then in-

[1] The drug may be easily sterilised by keeping it in 1-20 carbolic acid watery solution in a suitable glass bottle.

jected and the skin wound stitched up. In doing this it is well to include in the stitch not only the skin, but also the opening through the fascia. The use of the iodoform emulsion is not absolutely essential. Some cases seem to do as well without it; on the whole, however, we are of opinion that better results are obtained when it is employed.

In abscesses treated by this method the skin incision usually heals by first intention, and in a certain number of cases no re-accumulation takes place. In some, however, it is found that after a few weeks some deep-seated fluctuation is present, and this is not remarkable, since the actual cause of the abscess, namely, the spinal disease, is but seldom accessible to radical treatment (*i.e.* the removal of the primary focus of the disease). When accumulation takes place, and is found after a week or two to be increasing, a fresh incision should be made into the sac and the fluid again evacuated. The sac will be very much smaller than it was originally, and the fluid of a brown serous character containing iodine and iodoform. The sac wall should again be scraped, flushed out, and injected with iodoform and glycerine as in the first operation. In many cases two operations suffice to cure even a large abscess of this kind. In some, however, three or even more are requisite, but in the great majority of cases the patient can be got well in this way much more quickly and much more certainly than by the old plan of draining the abscess. Sometimes the wound, after healing by first intention, gives way and a small sinus forms in the scar. Should this happen, the wound must be opened up, scraped out thoroughly and stitched up as before, after the sinus has been carefully dissected out. If this be not done the sinus may take as long to heal as it was wont to do when the old plan of simple drainage was employed. Even should a sinus again form, the same procedure should be repeated.

The old plan, adopted by Lord Lister when antiseptic treatment first came into use, was to open and drain these abscesses, and, as a matter of fact, the great majority (from 70 per cent. to 80 per cent.) so treated healed ultimately, provided they were kept aseptic; but the healing was tedious, and on an average about eight months was required, and, of course, owing to the frequent dressings that were necessary, there was constantly a danger of sepsis.

It is needless to say that these operations must be performed strictly antiseptically; the entrance of septic organisms or even of saprophytes would very seriously endanger the patient's life. Before the introduction of antiseptic treatment very few cases of psoas abscess recovered.

Along with the local treatment of these chronic abscesses, the **general health** must be attended to on the principles already laid down, namely, good hygienic conditions, absolute rest to the part, and the administration of cod liver oil and nourishing diet. We shall have to deal with this subject of chronic abscess again in connection with tuberculous disease in the various organs. What has just been said will suffice to indicate the general principles of the treatment.

CHAPTER XV.

TUMOURS.

DEFINITION. Tumours may be defined as localised swellings which, though part of the body, tend to grow continuously and quite independently of it, and without relation to any known cause. When a tumour has formed it continues to grow and no means short of its complete removal will permanently arrest its development. It must be distinguished from hypertrophy on the one hand and from inflammatory swellings on the other. Hypertrophy is a simple increase in the size of an organ, which, however, still retains its natural form and structure and, as far as we know, its function; inflammatory growths do not possess any inherent power of increase, and only continue to grow as long as the causes which produce them continue to act.

Tumours grow either inside an investing capsule or they may be devoid of one, and they then grow by invading the surrounding tissues, destroying them and taking their place; in some cases minute portions of the tumour may be carried by the lymphatics or blood vessels to distant parts and there give rise to secondary growths.

It is unnecessary here to enter fully into the question of tumours because their treatment must be discussed in detail in connection with the various organs and tissues in which they occur. All that we propose to do is to make a few general remarks concerning them in order to save future repetition.

CLINICAL CLASSIFICATION.—Tumours may be classified both from a clinical and a histological point of view. Clinically they are divided into simple and malignant tumours.

Simple tumours.—By a simple tumour, as for example, an ordinary lipoma, is meant one which is of slow growth; which does not, unless situated in some vital organ, produce any constitutional disturbance, such as wasting or cachexia; which does not as a rule cause pain, unless from its situation, as for example when it happens to press upon nerves; which has no inherent tendency, by destroying the skin over it, to ulcerate and fungate, and only does so when the skin has been irritated from without.

A simple tumour is generally surrounded by a capsule and does not infiltrate the tissues around, nor does it recur after being thoroughly removed. It is freely moveable and readily separable from the surrounding parts, unless accidental attacks of inflammation have occurred about it; in structure it resembles more or less closely some of the normal tissues of the body.

Malignant Tumours.—A malignant tumour, for example, an epithelioma, on the other hand usually grows rapidly and after a time produces severe constitutional effects known as cachexia, the patient wasting, becoming pale and sallow, and evidently suffering from chronic poisoning. The growth is often painful of itself apart from its situation, and its tendency is to undergo softening, and, when near the skin, to destroy it and lead to ulceration and fungation. It is not encapsuled, any apparent capsule being really a false one and constituting part of the tumour itself. As a rule it grows by infiltrating and destroying the surrounding parts and replacing them by tumour substance, and also by producing secondary tumours elsewhere. Malignant tumours are often soft in consistence and not freely moveable on account of their infiltrating nature. They frequently recur after removal. In structure they differ more or less completely from normal tissues.

HISTOLOGICAL CLASSIFICATION.—Histologically tumours are divided into those composed of cellular elements and those in which the structure is more complex: the former are again subdivided according to the type of cell that forms their chief constituent. On the one hand they are divided into tumours composed of epithelial tissues, and on the other into tumours of the connective tissue type. The tumours belonging to this latter class are not composed of cells alone, but they contain in addition blood-vessels, connective tissue and lymphatic vessels. So far as we know however they are not provided with true nervous elements.

TUMOURS OF THE CELLULAR TYPE.

EPITHELIAL TUMOURS.

We shall in the first place refer very briefly to tumours in which the type of cell is essentially epithelial. They are due primarily to the growth of epithelium which may be regular or irregular and, if on a free surface, may remain heaped up in masses or may penetrate into and infiltrate the tissues beneath. The irregular infiltrating form of growth leads to the formation of malignant tumours, such as carcinomata; the regular non-infiltrating form gives rise to benign growths.

BENIGN VARIETIES.—Of this class we have two forms, namely, those where the epithelium is growing on a free surface,—the papillomata,—and those where the growth is in the substance of the tissues,—the adenomata. The papillomata do not strictly belong to the tumour group

because many of them are distinctly of irritative origin and sometimes spontaneously disappear; nevertheless it is most convenient to refer to them here.

Papillomata.—This group includes warts, or papillomata proper, corns and horns. **Warts** on the skin are usually hard and sessile, while on the mucous membrane they are soft and pedunculated. The papillæ of which they are composed may be single or branched, and it is the branched form which gives rise to the pedunculated growths of which the type are those seen on the prepuce.

Treatment.—A simple and effectual method of treating ordinary hard warts on the skin is to pare away the dense epithelium on the surface until the vascular tops of the papillæ are exposed, and then to apply some caustic, so as to destroy their bases; the one which answers best and which leaves the least scar is strong salicylic acid. The most useful form of application is a mixture of salicylic acid with flexile collodion in the proportion of 100 grains of the former to the ounce of the latter. After the wart has been shaved down so as to expose the papillæ, it is dried and painted over with the mixture. Twelve hours later, as much of the collodion as will readily come off is picked away and a fresh layer applied, and this is repeated night and morning; in the course of a week or ten days the wart will generally be found to have withered away. Should the action not be sufficiently rapid, the wart should be shaved afresh from time to time, so as to expose the base, and the acid again applied. This method may also be sometimes employed for gonorrhœal warts covering the prepuce, where a large raw area would be left if they were clipped off with scissors. Here it is not necessary to shave the wart before applying the caustic. The prepuce should be retracted, and the wart thoroughly dried and then painted with the salicylic collodion; this must be allowed to dry thoroughly before the prepuce is pulled forwards, as otherwise a sore on the glans may be produced by contact with the acid. In fact, it is best, after having painted the warts and allowed them to dry, to introduce between the glans and the prepuce a piece of dry boracic lint, which will both absorb moisture and at the same time prevent the contact of the salicylic acid with the mucous membrane on the opposite side.

Should this method of treatment prove ineffectual, the wart must be removed by the knife. When papillomata are sessile and are situated on the skin, it is not sufficient merely to clip them off, as they will certainly grow again; it is usually necessary to excise them.

When the papillomata are pedunculated, and the pedicle is narrow, it is best to clip them off at the base with scissors, and then next day and for a few days in succession, to paint the cut surface with salicylic collodion. The papillomata which occur on mucous membranes elsewhere, such as the bladder or rectum, must be removed by special methods of operation; these will be described in their appropriate places.

Horns.—In these cases the epithelium remains heaped up in masses

over the surface of the papillæ, and becomes hard and stuck together by some glutinous material. On breaking off the horn, a broad papillomatous base is left, and this must be dissected away. If this be not done, the horn will grow afresh.

Corns.—A corn is essentially due to intermittent pressure, and the complete removal of all pressure will as a rule lead first to the peeling off of the hard core of the corn, and subsequently to the disappearance of the whole trouble. This can be aided by salicylic collodion applied after paring the corn in the manner described in speaking of warts. A corn however needs more frequent paring than does a wart. If it be at all rebellious to the ordinary salicylic collodion, a more certain and rapid effect is produced by taking a thick corn or bunion plaster and, after shaving down the epithelium as much as possible, applying the plaster to it so that the central perforation is over the base of the corn. This is then filled up with pure salicylic acid which is kept in place by a small piece of ordinary plaster without any central hole put on over the corn plaster. The action of the pure acid is thus brought to bear directly upon the base of the corn and is very effectual.

Adenomata.—These tumours occur in connection with glands, and their structure is similar to that of the gland in which they develop. Whether they originate in a hyperplasia of the epithelium or of the connective tissue is a point which is by no means settled, but as a rule so much fibrous tissue is present that the term fibro-adenoma is more appropriate, or, if the tissue be very embryonic, myxo-adenoma. The adenomata are simple tumours which are usually encapsuled, and when embedded in the substance of the organ they can generally be shelled out of the capsule without any trouble and without any tendency to recurrence.

Treatment.—The treatment is to remove them and it is always best to take away the capsule. In certain positions adenomata become polypoid, for example, in the rectum, œsophagus, etc., where by their weight they are dragged downwards, pushing the mucous membrane before them. In these cases the removal of the polypoid growth, with ligature of the pedicle so as to arrest the bleeding, is the proper treatment.

MALIGNANT FORMS.—The second great group of epithelial growths is formed by the carcinomata, in which the epithelium grows in an irregular manner; the cells are larger than the ordinary epithelial ones from which they originate, and the growths infiltrate the tissues and are not encapsuled. They are malignant, and the essential elements in the tumour are the epithelial cells.

Carcinomata.—The carcinomata differ in malignancy and rapidity of growth according to their situation, to the character of the epithelium in connection with which they grow and to other circumstances with which we are not well acquainted. The carcinomata which spring from the surface epithelium are generally spoken of as **epitheliomata** and this class includes *squamous epithelioma*, and *rodent ulcer*, growing from the skin, and the

cylindrical epitheliomata, springing from the intestinal canal, etc. Those which originate from glandular epithelium are termed the carcinomata proper.

The **carcinomata proper** also form several groups. There is a very soft form called *encephaloid* cancer in which the cells are very numerous and the fibrous tissue very small in amount. They are exceedingly malignant, growing with great rapidity, and giving rise early to secondary deposits. In marked contrast to these is the *atrophic scirrhus*, where the cells atrophy very quickly, and the growth contains a large amount of fibrous tissue with but few alveoli and cellular elements. These tumours grow extremely slowly and never attain any great size. Intermediate between these two extremes are all sorts of gradations.

Mode of Spread.—The essential growing element in the carcinomata is the epithelial cell, and the character of the growth depends upon the mode in which these cells spread. In the malignant tumours the epithelial cells are usually found enclosed in tubular spaces termed alveoli, which are probably nothing else than dilated and much-altered lymph spaces; at any rate they communicate quite freely with the lymphatics. The cells are evidently derived from the normal epithelium of the part in which the disease primarily begins, but they very soon increase in size independently of it and show active processes of growth. They rapidly push their way through the limiting membrane of the normal epithelium into the tissues around and there spread in the lymph spaces and channels: at the same time it would appear from recent investigations that they also attack the walls of the smaller veins, and spread into their interior at a very early period, although metastatic deposits, due to infection through the blood-vessels, seldom show themselves clinically until late in the course of the disease.

After spreading into the lymphatic vessels, the cells become detached and are soon carried with the lymph stream, and either become lodged in the course of the vessels where the latter are small and the cells are large or massed together in groups; or they are carried on to the nearest lymphatic glands, where they are caught, and there give rise to secondary tumours. From the nearest lymphatic glands again they spread in the same way to others in the neighbourhood, and thus fresh groups of glands are affected. Ultimately they get into the blood-vessels, either indirectly through the thoracic duct, or directly by penetrating the walls of the veins. They are thus finally deposited in various organs in distant parts of the body. Hence, in carcinomatous tumours, we have a primary tumour, a secondary glandular infection and internal or metastatic deposits.

Furthermore, certain special **degenerations** occur in some forms, such as colloid degeneration in carcinoma of the stomach and intestine, and a form of degeneration accompanied by the deposit of pigment which is generally spoken of as melanotic cancer.

Treatment.—The only treatment of carcinoma that is at all likely to be of any avail is operative, and the best method in all cases is by the use of the knife. As will be mentioned later, some prefer in certain cases,

more particularly in rodent ulcer, the use of caustics, but in our opinion there is nothing that will compare with free excision by means of the knife as a method of cure. In any case, if carcinomatous disease is to be rooted out, its mode of spread by means of the lymphatic vessels must be borne in mind, and as this occurs at a very early stage, and as the cells are quite microscopic, a very wide area must be included in the operation. The organ from which the original growth springs should, if practicable, be altogether removed, because its lymphatic vessels generally communicate freely with each other, and secondary deposits have probably already taken place in various parts of it. In addition, the nearest chain of lymphatic glands must also be completely removed, even though they may not be noticeably enlarged.

It is sometimes difficult to decide whether the lymphatic tract intervening between the primary growth and the glands should also be removed. That this should be done in certain cases as, for example, in breast cancer, is evident from microscopical researches, which have shown that the lymphatic vessels passing from the breast to the axillary glands are in the great majority of cases themselves affected, at any rate if the disease be at all advanced. On the other hand there are certain forms of carcinoma, especially of the squamous epithelial type, where the intervening lymphatics do not as a rule seem to be readily infected. In epithelioma of the lip, for instance, although the glands of the neck may be enlarged, it is only rarely that a secondary tumour arises in the course of the lymphatic vessels. The same thing holds good, although perhaps not to so marked an extent, in some cases of epithelioma of the tongue; in epithelioma of the extremities also, in the leg for example, the lymphatic vessels in the thigh are not usually affected, although the inguinal glands become involved at a comparatively early period. Hence, our advice here is to remove the primary growth and the nearest lymphatic glands, and then to watch lest recurrence should take place in the intervening tissues. On the other hand, in breast cancer it is wiser, if we wish to make sure of avoiding recurrence, to take away not only the breast and the axillary glands, but, in addition, all the intervening fat and fascia with the lymphatic vessels running in them. Full details of the steps of the various operations will be given when dealing with the affections of the individual parts and organs.

TUMOURS OF THE CONNECTIVE-TISSUE TYPE.

These are of two kinds, namely, those where the connective tissue is of an embryonic character, such as the sarcomata and myxomata, and those where the connective tissue is more fully formed, such as the fibromata and lipomata.

BENIGN VARIETIES.—The other variety of embryonic connective-tissue tumour, namely, the **myxoma**, has the clinical characters of a simple tumour. The myxomata are soft, gelatinous tumours, consisting of tissue,

in which are found the characteristic branched ramifying cells, and often also a large proportion of the round variety. They contain elastic, fibrous and fatty tissue, and they possess but few capillary blood-vessels. They are encapsuled, nodular and soft, and yield a gummy mucous fluid on scraping. They are simple; they do not tend to recur if properly removed; they grow in the fat, in the subcutaneous and intermuscular tissues, in the skin, mucous membranes, nerves, salivary glands, etc., and they occur perhaps most often in the region of the parotid gland. They are slow-growing, well limited, mobile, soft and semi-fluctuating, and, in the case of the nerves, they may be multiple.

The **treatment** is to remove the myxoma completely, and with it the capsule, cutting through the healthy tissue beyond the tumour.

The **Fibromata** consist of fully-formed connective tissue; and they occur in two varieties—the soft and the hard fibroma. The **soft** form is more cellular than the hard, and contains delicate fibrous bundles not closely approximated. Its usual seat is on the skin, where it occurs either in the form of molluscum fibrosum or of moles. The **hard** fibroma is composed of dense fibrous tissue, showing a concentric arrangement around the vessels. The blood-vessels, especially the veins, have no sheaths, and remain open when divided. It is nodular, whitish-grey, creaks under the knife when cut, and contains large cavernous venous spaces. It occurs wherever there is dense connective tissue, in the skin, in the connective tissues, especially the fasciæ, in the nerves, periosteum, etc. The fibromata are simple tumours which grow slowly, and are only injurious when they press upon important structures. They undergo various forms of degeneration, such as serous infiltration, calcification, or cystic formation, the latter condition resulting from fatty or mucous degeneration.

Treatment.—The hard fibromata should be removed, and, where they possess a definite capsule, they may generally be shelled out of it with ease, but in many cases, where they occur in connection with the fasciæ, the capsule is not well defined, and it is necessary to take away this structure along with them. There is no tendency to recurrence after proper removal. In the case of soft fibromata the pedunculated molluscum fibrosum can be snipped off, and a very small scar is left. Moles can only be excised; they have no capsule. Care must be taken in removing a large fibroma not to cut into its substance, for the vessels are embedded in the tissues and are unable to retract, and large cavernous veins are often present, and therefore the bleeding may be very severe. This fact must be borne in mind in connection with fibromata in the naso-pharynx, where it is most essential to avoid cutting into the substance of the tumour on account of the most alarming and uncontrollable hæmorrhage which might result. If such an accident should happen, the tumour must be ablated as quickly as possible, when the vessels leading to it will generally very rapidly contract, and the hæmorrhage will cease spontaneously; even if this be not the case, the bleeding points will be much more readily accessible.

The **Lipomata** are tumours composed of fatty tissue which in structure resembles normal fat and is arranged in lobules with connective tissue between them. The cells are somewhat larger than normal fat cells. Sometimes the tumours contain a considerable quantity of fibrous or mucous tissue, and they are met with in two forms. One is termed the **diffuse** lipoma, in which there is a diffuse formation of coarse fat not surrounded by any capsule. It is usually met with at the back of the neck on each side of the spine, or over each anterior triangle of the neck, but it occurs also over the abdomen, the arms, and so forth. More frequently, however, the lipomata form **circumscribed** encapsuled tumours, which are very soft and lobulated; there is often only very delicate tissue connecting the lobules with the main tumour. They are usually smooth on their deeper surface, and when growing in the subcutaneous tissues they penetrate among the fibrous bands connecting the under surface of the skin with the tissues beneath, so that the skin does not move quite freely over them. They possess a more or less well-defined capsule, out of which they are readily shelled. They occur at all ages and grow slowly, and are met with especially in the subcutaneous tissues where fat is abundant, such as the back of the neck, the front of the thigh, over the abdomen and the arms, in the axillæ, in the buttocks, etc.

Treatment.—(*a*) **Of the encapsuled variety.**—These growths are readily removed, and shell out of their capsule without any trouble, but great care must be taken to see that none of the outlying lobules are detached and left behind, as lobules so left will grow again and form the starting point of a fresh tumour. The best way to remove a lipoma is to squeeze up the tumour forcibly between the thumb and forefinger of the left hand and make the skin very tense. Then, on incising the capsule and the parts over it freely, the lipoma is forcibly projected through the incision, and its complete enucleation is insured. Difficulty may arise when they occur in parts subject to pressure. Here inflammation, leading to adhesions between the tumour and the skin covering it, or the structures over which it lies, is not uncommon. In such cases care must be taken to remove the whole of the tumour, and it is generally best to remove the adherent skin as well.

(*b*) **Of the diffuse variety.**—The whole of a diffuse lipoma cannot, as a rule, be removed, but considerable improvement, at any rate as regards appearance, can be effected by excising as much of it as possible; in doing this care must of course be taken to avoid damage to important structures, such as nerves, etc.

Chondromata are tumours consisting essentially of cartilage, of which they may embrace all varieties, including the ramified cell form without capsule usually found in embryonic conditions and in some of the lower animals. For the most part the cartilage resembles the normal hyaline variety, but it differs from it in that the vessels penetrate into the cartilaginous nodules.

The tumour is composed of an aggregation of nodules of cartilage separated by fibrous tissue, and is encapsuled.

Chondromata form rounded or lobulated tumours, and in the course of their growth they may surround various structures, such as tendons, nerves, or vessels, without actually destroying them. On section they are usually semi-transparent, greyish-blue, firm and elastic, or soft, and they show a lobulated structure. They occur especially in the phalanges and metatarsal bones, in the jaw, in the pelvis, or about the epiphyses of long bones. Sometimes also they occur in soft parts, such as the parotid, the sub-maxillary glands, and the testicle; but it is a question whether chondromata occurring in the soft tissues are not really chondrifying sarcomata rather than true chondromata. At any rate in the case of the testicle, these tumours are generally malignant, and give rise to secondary deposits in the lungs, and the same chondrification takes place there. Chondromata may undergo calcification; fatty or mucous degeneration, leading to the formation of cysts may be met with in them. They grow slowly and cause trouble chiefly from their situation, and, with the exception of the variety met with in the soft parts already mentioned, they are benign tumours; in the case of the phalanges they are often multiple.

Treatment.—When situated in the soft parts the best treatment is early extirpation; the capsule should not be left behind because of the possible malignant nature of the tumour. When the growth springs from a bone, it is sufficient to clip it freely away, or, if situated in the interior, to scrape it out without performing amputation. Care must be taken to do this as completely as possible, because recurrence from lobules of the cartilage being left behind is apt to take place. Should this happen, enucleation may be repeated, or if the bone be so much destroyed by the growth as to be useless, as may, for example, be the case in a phalanx, it is best to amputate.

The **osteomata** are tumours composed of bony tissue, and are met with in two chief forms. The rarer of these is the hard or **ivory** osteomata or exostosis, which is a flat sessile bony mass chiefly occurring on the vertex of the skull, on one of the bones of the face, or in the external auditory meatus; it is of ivory hardness, and is formed of dense compact bone, containing lacunæ and canaliculi, but without proper Haversian canals. The other form is the **spongy** exostosis, which resembles cancellous bone in structure and arises generally in the neighbourhood of the epiphyseal lines. During the period of growth these spongy exostoses are covered with a layer of cartilage, and it is from this part of the tumour that growth takes place. As a rule this cartilage very quickly ossifies at the point where the tumour joins the bone from which it arises, and then growth ceases there whilst it goes on at the periphery of the tumour; hence these growths are usually pedunculated, and they vary in size and are nodular on the surface.

Treatment.—The treatment of the **spongy** exostoses is to clip them

through at the base. If this be done where growth has ceased and cartilage does not exist, recurrence will not take place. The only danger of this operation is the possibility of sepsis. In former days, before antiseptic treatment was employed, many patients after operation developed a suppurative osteomyelitis, and either died or had to lose the limb; hence in operating the greatest care must be taken in the aseptic management of the wound.

The small **ivory** exostoses when growing on the outside of the skull are seldom of sufficient size to require operation. Their removal is always difficult and dangerous because, owing to their density, the force required to chip them off sometimes fractures the skull. Hence it is as a rule best to leave them alone, but in some cases, where they are pressing on the eye, ear or other important parts, or growing internally, it may be necessary to undertake their removal. If the growth be comparatively small it may be possible to remove it by using a large trephine: this is made to encircle the tumour, and by cutting through normal bone all around, the exostosis and the base from which it springs can be removed entire. In the larger growths this is however impossible, and the only way that offers a chance of getting them away without very great trouble is to drill a number of holes through the base of the tumour in all directions by means of a dental engine, and then to join these together with a saw and thus complete the removal; in the ear it is sometimes possible, owing to their brittleness, to break them off by means of a sudden smart tap, after their base has been drilled. Attempts to remove them by repeated applications of sulphuric acid, as is sometimes recommended, should never be made: it is far better to adopt one of the methods above recommended. If the growth be very diffuse, and must be removed, it may require more than one operation for its satisfactory treatment.

Bony growths which do not properly come under the heading of osteoma are also met with elsewhere; among these may be mentioned the bony growths which occur from irritation in the adductors of the thigh in riders, or in the deltoid muscle in soldiers; they will be dealt with later.

MALIGNANT FORMS.—The **Sarcomata** form fleshy tumours composed of embryonic connective tissue. They are rounded, nodular and generally have a spurious capsule, which is composed of sarcomatous tissue and must be looked upon as an integral part of the growth itself. They vary in malignancy, but they all possess to a greater or less extent a decidedly malignant character. They may occur wherever there is connective tissue, and are most frequently met with in bones, fasciæ, muscles, skin, the breast, the testicle, the uterus, the kidney, the parotid, the nerves and so forth. The cells vary in character and the sarcomata are therefore sub-divided into a number of varieties according to the general character of the cells composing them. In addition to the cells there is a certain amount of inter-cellular substance which varies in degree and stage of organization according to the class of the tumour. The consistence and

appearance of the tumour depends to a great extent on the amount of inter-cellular substance present.

These growths are usually very vascular and are especially rich in capillaries and veins. They tend to undergo various degenerations; they compress and destroy neighbouring parts, surround vessels and nerves, and may lead to ulceration of the skin, either after involving it or, more commonly, by causing sloughing from pressure and then fungating through the opening thus formed. They give rise to secondary tumours around the primary one, or spread through the medium of the circulation. The secondary internal tumours occur most commonly in the lungs and liver. In certain cases, generally in the softer and more embryonic varieties, the lymphatic glands become affected, though this is not nearly so common as in the carcinomata.

Of the different varieties of the sarcomata we may mention the **round-celled sarcoma**, which is usually soft and white like the milt of fish, and which is generally very malignant; the **spindle-celled sarcoma**, which is generally much firmer, of a greyish or yellowish-white appearance and not so malignant in its nature as the round-celled variety; it occurs most frequently in connection with the fasciæ: the **myeloid sarcoma**, where, in addition to polymorphous or spindle cells, there are large myeloid or giant cells. This form is soft, of a chocolate colour, and generally contains large numbers of cysts, due to degeneration occurring in the first instance in connection with these myeloid cells. It occurs in connection with bones, more especially in the interior of their articular ends, and in the lower jaw, and is usually an endosteal growth. It is the least malignant of all the sarcomata and seldom gives rise to secondary tumours; in some cases it may be removed without amputation and without recurrence. Some authors separate these myeloid tumours from the sarcomata and place them in a group by themselves.

The **melanotic sarcomata** contain polymorphous or spindle-shaped cells in which pigmentary degeneration occurs very early. They originate in parts where there is normally pigment, for example in connection with the skin or the choroid coat of the eyeball. They are the most malignant of all the sarcomata and affect the glands early, and recur with great rapidity. **Alveolar sarcoma** is comparatively rare. In it the cells are arranged in groups separated by connective tissue or spindle cells, giving rise to an alveolar arrangement. It usually occurs in connection with the skin.

Lastly, there is **osteo-sarcoma** which takes origin from the periosteum. This form is extremely malignant; in it a certain amount of ossification takes place so that when the affected bone is macerated, a considerable number of spicules of osseous tissue are found projecting from its surface. The secondary deposits to which this form gives rise are very apt to undergo similar ossification. A somewhat analagous condition is seen in the variety known as the **chondro-sarcoma**, which is a form of sarcoma met

with sometimes in the soft tissues, such as the testicle or the parotid, and in which chondrification occurs; it is a very malignant form.

Treatment.—The treatment of sarcomata should in all cases be free excision. Special care must be taken to see that any capsule that the tumour possesses is completely taken away, and in fact it is well to ensure that a considerable area of healthy tissue beyond the capsule is included in the removal. Where the sarcomata arise in connection with bone, amputation is generally necessary, and in cases of periosteal sarcoma it is moreover advisable to amputate through the joint above the bone affected, because it will be found on microscopical examination that the growth generally spreads in the periosteum to a considerable distance beyond the naked-eye limits of the tumour, and recurrence is very likely to take place if amputation be performed in the continuity of the bone.

Myeloid tumours however form an exception to the rule that sarcomata of bone call for amputation. Such a procedure is rarely called for in them. If the growth be of any size and occupy the whole thickness of the bone, a free excision of the affected area will suffice: where the growth is in the articular end a partial excision of the joint will be called for. Where however the growth is small and only occupies a small part of the thickness of the bone, so that sufficient bone will be left to bear the weight of the body, it is not even necessary to excise. The growth may in these cases be thoroughly scraped out without much fear of a recurrence, though it is well, perhaps, to take away a thin slice of the wall of the cavity.

The **prognosis** in all these tumours, if left to themselves, is very grave. With the exception of the myeloid sarcoma they are, under any circumstances, always dangerous to life. On the whole, the result of operation is more favourable than in carcinoma, except in the case of melanotic sarcoma and the osteo-sarcomata, which are extremely malignant forms. With regard to the others, although recurrence is not at all infrequent, it is very often only local, and in most cases these secondary tumours may be removed again and again as soon as they appear. In all cases a wide sweep must be made of the parts, and a considerable amount of the tissues around must be taken away. There must be no attempt in any case to shell the growth out of the capsule. As to the mixed forms, such as myxo-sarcoma and fibro-sarcoma, the treatment is the same as for the others.

TUMOURS COMPOSED OF THE MORE COMPLEX TISSUES.

Amongst the tumours composed of more complex tissues are those consisting of lymphatic tissue, or lymphomata, of muscular tissue or myomata, of nerve tissue or neuromata, of blood-vessels or angiomata, of lymphatic vessels or lymphangiomata, and complex tumours and cysts.

Lymphomata are composed of lymphatic tissue and occur primarily in glands or in parts where lymphatic tissue is normally found; they

present the same structure as the lymphatic glands, that is to say a delicate reticulum with leucocytes entangled in it. These lymphatic tumours vary in malignancy, but the typical lymphadenoma is a very malignant tumour indeed. It occurs in glands, generally beginning in the neck or the axilla, and very soon the growth of adenoid tissue spreads beyond the gland capsule and infiltrates the tissues around. Adhesion of the gland to the surrounding structures soon occurs, and thus a nodular mass is formed composed of a multitude of glands united by adenoid tissue. Other groups of glands soon become involved and, in addition, tumours composed of lymphatic tissue may appear in parts where this is not normally present, as for example in bones. The disease goes on and is accompanied by increasing pallor of the patient, but not at first by emaciation. Ultimately death takes place from exhaustion.

Treatment.—The treatment of lymphadenoma is very unsatisfactory. Excision of a mass of lymphadenomatous glands seldom arrests the progress of the disease, even although the whole of the affected area may apparently be entirely removed. Other glands soon enlarge and recurrence often takes place in the neighbourhood of the primary growth. Hence, except at a very early stage, or where its situation is such that the growth causes much suffering from pressure upon important organs, excision cannot be recommended; even at an early stage it is a procedure of very doubtful value.

Various drugs are said to exercise a certain degree of restraining influence on the growth of these lymphadenomata, but the results obtained from their administration are also highly unsatisfactory. The one usually ordered is *arsenic*, and it is most commonly given in the form of Fowler's solution, beginning with three minims in water three times a day after meals and increasing it by one minim every day or two so long as it can be borne without causing intestinal irritation, a condition which manifests itself by nausea vomiting, colic, and diarrhœa. When this occurs the arsenic should be left off for a few days, and then, when the condition has passed off, the drug may again be given in smaller doses, which should be cautiously increased. Some have advocated the injection of Fowler's solution into the tumour, quantities varying from two to six minims being introduced once a day; there is no convincing proof of the advantage of using the drug in this way. Abroad, *phosphide of zinc*, in doses of a twentieth of a grain in pill form three times a day, is very often ordered. On the whole, arsenic is probably the most efficacious drug, but permanent benefit can hardly be hoped for from it.

Myomata are tumours composed of unstriped muscular fibre, and they are met with where unstriped muscular fibre is normally present, as, for instance, in the uterus, the prostate, the wall of the œsophagus, the stomach, and the intestines. In the latter situation they generally project into the lumen of the gut, forming pedunculated polypi, covered by the lax mucous membrane. Myomata may be single, but they are more often multiple;

they form round lobulated tumours with an investing fibrous capsule, and on section they resemble fibromata except that they are of a purplish colour. They are generally very vascular, more especially at the periphery, where large venous sinuses are numerous. They occur in adults, and cause trouble from their size and their tendency to bleed.

Treatment.—This depends mainly upon their situation, and the consideration of the treatment must, therefore, be deferred until the particular organs in which they occur are dealt with.

Neuromata are tumours composed of nerve tissue. True neuromata are very rare, if, indeed, they ever occur; the tumours generally spoken of as neuromata are inflammatory thickenings occurring in the course of nerves, such, for example, as the enlargements at the divided ends, or tumours, such as myxomata, fibromata, or sarcomata, occurring in the neighbourhood of and involving nerves. In connection with these neuromata may be mentioned the **gliomata**, which occur in the central nervous system, and the retina, and which are composed of neuroglia. They are often vascular, and, as a rule, they are not malignant except locally; but the gliomata which occur in connection with the retina are more malignant, and possibly ought to come under the definition of sarcoma.

The **treatment** of neuromata will be considered among the affections of nerves. The treatment of glioma is removal wherever possible; the subject will be dealt with more fully in connection with tumours of the brain.

Angiomata or nævi are composed of vascular tissue, and the essential element in them is the formation of blood-vessels. The latter are partly of new formation and are partly pre-existing vessels much dilated and thickened. These tumours are divided into two groups—the simple or capillary, and the cavernous or venous form.

In the **capillary** angioma the vessels are distinct and have well-defined walls, and the tumour simply consists of a mass of dilated tortuous capillaries, derived not only from dilatation of old capillaries but also from the formation of new ones. There is no definite capsule, and, therefore, the tumours are not clearly marked off from the surrounding tissues, their outline being irregular and somewhat lobulated. They occur usually in the skin, and may be either upon its free surface or in its substance, and they may spread from the skin to the subcutaneous tissue. The tumour generally presents a bright red colour, but where the circulation is slow it may be somewhat bluish.

The **cavernous** angioma, the so-called venous nævus, occurs in the skin, subcutaneous tissue, or muscles, and, like the corpus cavernosum, is composed of erectile tissue. This is made up of large spaces comunicating with the blood-vessels and separated from each other by septa of unequal thickness containing fibrous tissue, remains of the original tissue, elastic fibres, striped and unstriped muscle, fat cells, vasa vasorum, lymphatics, and nerves, the blood spaces themselves being lined with

endothelium. The great majority of these venous nævi are congenital (in fact both kinds of nævi generally are), and they may disappear as the child grows older, or they may increase in size; this is more frequently the case with the subcutaneous or cavernous form. Sometimes they undergo cystic degeneration, the communication between the blood spaces and the vessels being obliterated, and the former then undergoing dilatation, so that cysts of variable size are formed.

Treatment.—The treatment of nævi may be divided into (1) excision, and (2) the use of methods which aim at setting up inflammation in the vessels so as to procure first thrombosis and ultimately complete atrophy of the vascular growth.

(*a*) **Excision.**—Of excision it may be at once said that it is certainly the best possible method of treatment, and that it should be adopted in all cases where it is possible to carry it out. It presents the following great advantages over all other methods. It is certain and rapid in its results, the affection being cured permanently within a fortnight; there is no pain attending the after-treatment if the wound be, as it should invariably be, kept aseptic; no frequent change of dressings is called for, and there is not, therefore, the liability to septic infection which is almost inevitable where the opposite is the case. The cases that are most frequently met with in practice are those where there is a moderate sized nævus of the capillary variety, with or without affection of the subcutaneous structures, and this form of the affection is certainly best treated by enclosing it in an oval incision well free of the growth and cleanly excising it. A large nævus may not be suited for excision either because its size renders the operation formidable from loss of blood, as may be the case in infants, or from the difficulty that may be met with in bringing the edges together subsequently. In the former case a good plan is to adopt one of the methods to be described immediately for procuring thrombosis, and when a sufficient amount of the tumour has thus been obliterated the rest may be excised. In the latter case most superficial nævi can be satisfactorily treated by excision followed by undermining of the skin so as to secure apposition of the cut edges. Where the area is too extensive for this, Thiersch's skin grafting is preferable to the scarring that inevitably follows upon other methods. Even on exposed parts the scar left by the operation is not so noticeable as that which results from other modes of treatment. As long as the nævus is superficial it will very rarely be found too extensive for treatment by excision, especially if Thiersch's grafting be employed; several partial operations may be required.

Where the surgeon has to deal with a deep-seated cavernous nævus, which is fairly limited, and does not involve any important structure, complete excision should also be attempted. There is no particular danger in excising a nævus. It should be done strictly antiseptically, and if care be taken to cut well beyond the tumour, there is no bleeding of importance, the vessels actually dilated being those within the growth

itself; those that are divided in the operation are merely the isolated afferent and efferent trunks which are easily secured as they are cut. It is of course important not to cut into the growth, as otherwise the hæmorrhage may be profuse and controlled only with the utmost difficulty. Where, however, the nævus is partially superficial and partly deep, involving structures which cannot be readily removed, such as the lip, or even more important deeper structures, then excision is not advisable, and in these cases other methods must be employed; of these we shall describe two, namely (1) electrolysis, and (2) injection.

(*b*) **Electrolysis.**—Of these methods the former is undoubtedly the better. In using electrolysis for nævi, different effects are produced by the positive and negative poles; at the positive pole a clot forms which is firm, hard, and readily organised, whilst at the negative it is soft and frothy, and of little value in the formation of new tissue. Hence it is the positive pole which is chiefly relied on to produce the local effect. Several needles connected with this pole should be introduced into the swelling at various points, especially in the neighbourhood of the veins which leave it. The needles should be insulated by means of shellac or guttapercha, or some similar material, right up to within a quarter of an inch of the point, and should be pushed into the nævus until the insulated portion lies in the hole in the skin. If the needle be not properly insulated where it passes through the skin it will produce a slough which will not only leave a scar but may also be a point of entrance for septic material into the clot. Care must be taken that the points of the needles do not approach too near the surface of the tumour, whether it be skin or mucous membrane, for, even if they do not actually perforate it, they may lead to sloughing and subsequent sepsis; this is particularly likely to happen if the points of several needles are close together. If more than one needle be introduced into the nævus, care should be taken to keep them parallel to each other, so as to ensure equable diffusion of the current and avoidance of sloughing (see Fig. 63). A useful and ingenious handle has been suggested by Dr. Lewis Jones for this purpose (see Fig. 64). By its means the needles are kept parallel while, if it be desired to insert both positive and negative electrodes in the tumour, this can also be done. Previous to their introduction the needles should be rendered aseptic by boiling; it is well not to immerse them in strong carbolic lotion, as that destroys the insulating material, and, if steel needles are used, an immersion in a 1-500 perchloride solution would damage the metal. As a rule platinum needles are to be preferred; the only drawback is that it is impossible to get a good sharp point to them. After the needles attached to the positive pole have been inserted in the manner just described, a large flat pad attached to the negative pole and moistened with salt solution is placed on the skin either over the spine or somewhere in the neighbourhood of the nævus. The pad must be moved from one point to another as the electrolysis proceeds, so that it shall not act too long at one spot; if it does, a slough may result.

In large nævi both poles may be buried in the tumour, the negative pole being attached to a single needle insulated as described above, which is

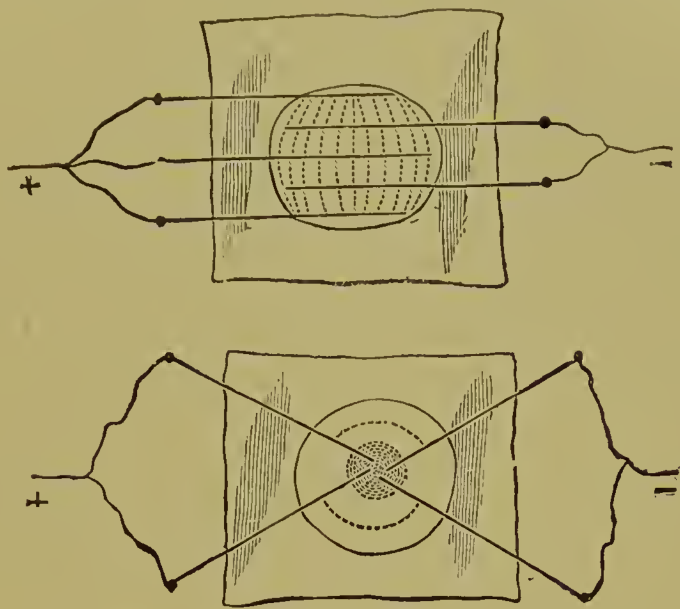

FIG. 63.—METHODS OF INSERTING THE NEEDLES IN ELECTROLYSIS OF A NÆVUS. The upper figure shows the proper method, viz. where the needles are kept parallel, and the current is uniformly diffused over a large area, and therefore produces uniform results. In the lower figure the needles are in an improper position, the current being concentrated at the centre of the tumour, which is therefore likely to slough, while the periphery will hardly be acted upon at all. (Lewis Jones.)

also pushed into the swelling. For this purpose the handle figured below (see Fig. 64) is specially useful. The strength of the current should be from 40 to 80 milliampères, but, where three or four needles are used, 20 to 25 will suffice. The current should be continued for about ten minutes;

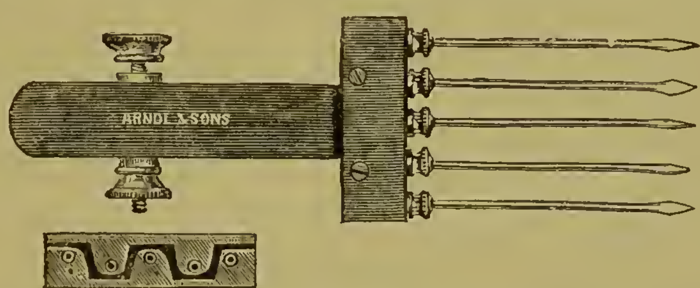

FIG. 64.—BIPOLAR FORK ELECTRODE. From two to five needles can be screwed into the handle. They are so arranged as to be alternately positive and negative, the method of insulation being shown in the smaller figure. (Lewis Jones.)

the best criterion as to when to discontinue it is perhaps that the nævus is felt to become firm. Before withdrawing the needles the current should be reversed for a few seconds, as otherwise those connected with the positive pole adhere firmly to the tissues and bleeding results from their withdrawal; this is however not of any real moment, very slight pressure being always sufficient to check it.

The skin should be thoroughly disinfected before the operation (see p. 161), and after it a little salicylic wool may be applied over the puncture, fixed on with collodion and allowed to remain till healing has taken place. The electrolysis causes a good deal of pain, especially at the make and break of the current, and when its strength is increased, and it is therefore well to employ a general anæsthetic. The current should be increased very gradually and, *vice versâ*, when the operation is completed it should be gradually diminished and not shut off abruptly, as otherwise considerable shock may be caused. Similarly, before reversing the current, its strength should be decreased gradually almost to nothing. When the nævus is situated over the fontanelle of a young infant, a careful watch must be kept on the pulse as the current is gradually increased. If any sign of shock be noticed, the current must be at once diminished or shut off entirely.

As the result of the electrolysis the nævus becomes hard, and this hardness may sometimes last several weeks before it entirely disappears. If the nævus be of any size, one sitting is very rarely sufficient for a cure, and, therefore, as soon as the hardness has subsided sufficiently to show what portion requires further treatment, the application is repeated; at first this may be done at intervals of from eight to ten days. After three or four sittings, however, the greater part of the nævus will have become firm, and then longer intervals must be allowed, because it is impossible to judge how much remains to be done until the hardness has more or less completely disappeared.

(*c*) **Caustics.**—Besides these extensive and important nævi, there are the small superficial capillary stains, of small size and insignificant proportions in which it is not worth while to have recourse to excision. The particular method to be employed will depend to a great extent on the size and situation of the tumour. Where there is simply a slight superficial nævus affecting the surface of the skin, the application of some irritant substance will suffice. The most popular is the solution of *ethylate of sodium*, (one part to eight of ethylic alcohol) which is painted over the part once a day for three or four days, and which usually leads to a sufficient amount of inflammation without causing any marked scarring of the skin. It causes a little pain at the time of application, but this is very slight and passes off immediately; no dressing is required. After the application a small crust forms, and this is allowed to dry up and drop off when, if the application has been sufficient, the nævus will be found to be cured: should any of the nævus tissue still remain, the application may be repeated. *Nitric acid* is sometimes used, but it leaves a distinct scar and is decidedly painful both at the time of application and subsequently.

For very tiny nævi or red points, a good method of treatment is to draw through them a needle armed with a very fine silk thread which has been dipped in liquefied *carbolic acid*. The skin all around where the needle enters should be covered with lint dipped in a 1-40 solution of

carbolic acid, so that the thread does not come into contact with it, as otherwise it would cause a burn and give rise to a scar. After the thread has been passed through it is withdrawn, pressure is applied for a little until the bleeding stops, and then the puncture is covered with collodion. The old method of vaccinating upon these minute nævi is a good one if they are very small, superficial, and in a suitable situation.

(*d*) **Injections.**—Another method is by injection of coagulant materials. The drugs used—carbolic acid, perchloride of iron, etc.—act by causing thrombosis of the vessels and subsequent obliteration; before injecting any coagulating material into a nævus it should, however, be an invariable rule to see that all connection with the general circulation is completely cut off, as otherwise fatal embolism or even general thrombosis may occur. In parts such as the ear or lip this may be done by grasping the whole thickness of the part on the proximal side of the nævus with rubber-covered forceps. In most cases, however, the only safe plan is to pass a ligature or series of ligatures beneath the base of the nævus, so as to completely command the circulation through it, and then to tighten them up. When the nævus is large, its base may be transfixed with a hare-lip pin, and then, at right angles to this pin and beneath it, a straight needle is passed through the tumour, carrying a long stout silk ligature, the ends of which are of equal length. The thread is drawn well through, and divided close to the needle, and thus two ligatures are left traversing the tissues beneath the base of the nævus. The ends of one of these threads are brought round beneath one end of the hare-lip pin and tied as firmly as possible, and the same is done on the other side with the second thread, and in this way the nævus is completely strangulated. The object of the hare-lip pin is to make sure that the thread encircles the base of the nævus; without it, it is almost certain to slip, and the circulation will not be properly commanded.

When the nævus is so extensive that the above method would not properly command the circulation through it, its base may be tied off by a succession of ligatures till the whole tumour is thoroughly strangulated. Thus, in the case of a nævus involving the lower lip, the method will be clear from the accompanying diagrams (Figs. 65 and 66); we may say in passing that this method of ligature is of use in other cases, such as in the removal of portions of the omentum. A needle carrying a long thread, the ends of which (A and B) are of equal length, is passed through the whole thickness of the lip beyond the nævus and near one side of the growth. It is then passed back from within outwards at a little distance away, a sufficiently long loop being left, then back again as shown in the diagram, as often as is necessary to effectually strangle the base. Thread A is then cut at *b*, *c*, and *d*, and thread B at *f* and *g*, and we are thus left with a series of ligatures, *ab*, *b'c*, *c'd*, *ef*, *f'g*, *g'h*, which, when firmly tied, completely cut the part off from the general circulation. If it be desired to command the circulation through a very extensive nævus situated upon

a flat surface, it may be done in a manner quite similar to the above. The threads are passed, divided, and tied in an exactly similar manner; the only important difference is that, as the deeper limits of the tumour are not so easily defined as when it is situated upon the lip, greater care

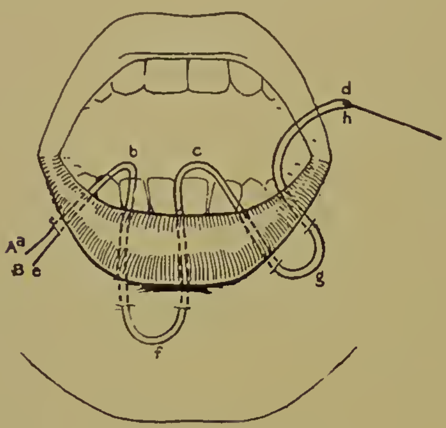

Fig. 65.—Temporary Strangulation of a Nævus. *Method of passing the sutures.* The dotted lines indicate the threads traversing the thickness of the lip, the continuous ones indicating them as they emerge from the cutaneous and mucous surfaces.

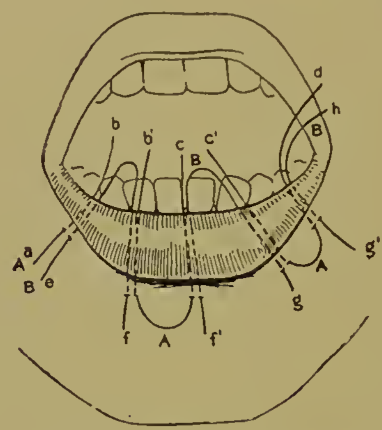

Fig. 66.—Temporary Strangulation of a Nævus. *Method of dividing the ligatures.* It is easily seen from the diagram how the circulation is completely controlled by tying together the corresponding ends of the ligatures.

must be taken to ensure the thread being passed below the base of the tumour. This is facilitated by pulling up the nævus from the deeper parts as the needle is introduced.

After having completely shut off the tumour from the general circulation by one of these methods, small quantities of coagulant material may be injected into its interior at various points by means of a hypodermic syringe. The best material is *undiluted carbolic acid*, and half or a quarter of a minim may be injected in numerous places, the needle being pushed into the nævus in various directions. After the injection the ligatures should be left on for at least ten minutes, when they may be cut and removed; by that time coagulation will be complete, and there will be no risk of the coagulating material getting into the circulation and causing embolism or a general thrombosis, both of which accidents have happened where coagulants have been injected without taking proper precautions to shut off the circulation. In making the injections care must be taken not to let the point of the needle approach too near the surface; if it does, a slough of the skin or mucous membrane and the subsequent introduction of sepsis may result. After the needle is withdrawn, pressure is applied over the puncture, which, when the bleeding ceases, is painted over with collodion. Other coagulants, such as perchloride of iron, tincture of iodine, etc., have been employed, but they are not so satisfactory or so safe in their action as carbolic acid.

When carbolic acid has been injected in this way, the growth becomes hard, partly from coagulum in the vessels, and partly from inflammatory

products, while later on the new material is gradually absorbed and the portion of the nævus within reach of the action of the acid is cured. When the thickening has subsided, it will be possible to see what portions have not been acted on and require further treatment.

Ligature.—We have not described the treatment of nævi by means of ligature or strangulation alone. This plan, which was formerly much in vogue, is open to so many objections (among which the principal are its tediousness, painfulness, and the almost inevitable introduction of sepsis) that we cannot recommend its use in any case. The strangulation of the nævus was effected in a similar manner to that employed for the temporary arrest of the circulation during injection of carbolic acid (see p. 269), but the ligatures were left to cut their way out by a process of ulceration.

Lymphangiomata are tumours composed of lymphatic vessels of new formation, and it is often very difficult to separate them from lymphangiectasis or varicose lymphatics; they are congenital circumscribed tumours. Three **varieties** are described:

(1) The **simple lymphangioma** consists of dilated lymphatic vessels of the size of capillary blood-vessels; tumours of this nature occur in the perineum, in the sacral region, in the axilla, etc. In some cases the dilated vessels are considerably larger, as is seen in the tongue in one form of macroglossia, and also in the lips, where it goes by the name of macrocheilia.

(2) **Cavernous lymphangiomata** are spongy masses composed of lymphatic vessels very closely resembling venous nævi in structure, which are found in the neck, in the sacral region, the lips, etc., generally in the subcutaneous tissues, but often deeper.

(3) **Cystic lymphangioma** is a congenital agglomeration of cysts of various sizes which may or may not communicate with each other or with lymphatic vessels. They are seen most frequently in the neck, where they have received the name of *hydrocele of the neck*; they are also met with in the perineum, buttocks, thorax, etc.

Treatment.—Operative interference, such as excision, was generally followed in former times by suppuration in the lymph spaces, and this led to extremely serious results. Nowadays of course this risk is greatly diminished, but in operating upon these cases it is necessary to be particularly careful as regards asepsis. In the majority of instances *electrolysis* is the best treatment, and it should be carried out in the same way as for nævi (see p. 266). In other cases, especially in the cystic forms, injections are employed, such substances as iodine or undiluted carbolic acid being used in the same way as for hydrocele of the tunica vaginalis. In the smaller forms excision is frequently practised, but, as has just been said, great care must be taken to ensure the asepticity of the wound.

Cysts.—This is perhaps the best place to refer to the various forms of cysts; the true cysts are those of new formation, and are not produced

by obstruction of pre-existing canals or by degenerative changes. Cysts may be unilocular or multilocular, and are found in the ovary and in the breast. In the ovary, multilocular cysts form large tumours generally composed of one or two very large cysts, and numbers of smaller ones. The walls are smooth and shining, the contents a clear fluid or a turbid, glairy material; papillary outgrowths are not uncommonly present in their interior. The cysts of the breast are similar in character, but smaller, while the intra-cystic growth may be more markedly developed. The whole subject of ovarian and mammary cysts will be dealt with under diseases of those organs. Other cysts are met with as the result of degeneration in tumours; or again they may be due to the dilatation of previously existing cavities, such as sebaceous cysts, hydro-nephrosis, hydroceles, etc., but these cannot be classed as true tumours.

Complex Tumours.—Lastly we have complex tumours, which may be solid or cystic, which are congenital and which generally contain a variety of tissues. These complex tumours are most frequently met with over the sacrum, forming the *sacro-coccygeal tumours*, and in them may be found a variety of structures, such as bone, connective tissue, muscle, nerves, cartilage, epithelium, etc., cysts also are often present. Another form of congenital complex tumour is the dermoid cyst, the lining wall of which is composed of structures resembling skin, containing the skin glands as well as hairs, and often teeth and even bone. They occur in the ovary and in various parts where epithelial structures may have been included during development, more particularly in the neck in connection with the branchial clefts and about the root of the nose or the angular process of the frontal bone.

The **treatment** of these tumours will be referred to when we treat of the affections of the organs in which they occur.

INDEX.

PART I.

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